PRODUCT ENGINEERING

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McGRAW-HILL PUBLISHING CO., INC. FEBRUARY 1938 VOLUME NINE, NUMBER TWO

Can There Be Progress Without Profit?

AMONG THE "practices which most people believe should be ended," listed by President Roosevelt in his recent message to Congress was, "the use of patent laws to enable larger corporations to maintain high prices and withhold from the public the advantages of the progress of science. . . . The enumeration of these abuses does not mean that business as a whole is guilty of them."

Admittedly, the monopolistic privileges granted by patents are sometimes abused, not only by larger corporations but by individuals as well. The President did not recommend or suggest legislation to cure the evil, but having brought the matter to public attention it is likely that from some source or other a legislative program for the reform of the abuses of patent privileges will be suggested, requested or instituted.

We do not take issue with the President. We believe he made an honest statement, properly modified as to the limited scope of its application. But many people, laymen especially, not acquainted with the facts relating to research and product development, and enthusiastically in sympathy with any scheme that promises price reductions, will be likely to misunderstand.

Whether or not the selling price of a patented article is excessive is usually solely a matter of opinion. But regardless of that, the primary purpose of patents is to guarantee the inventor a monopoly, for a limited time, to enable him to get as much as the public is willing to pay for the benefits derived from the use of the patented product and thus encourage inventive genius.

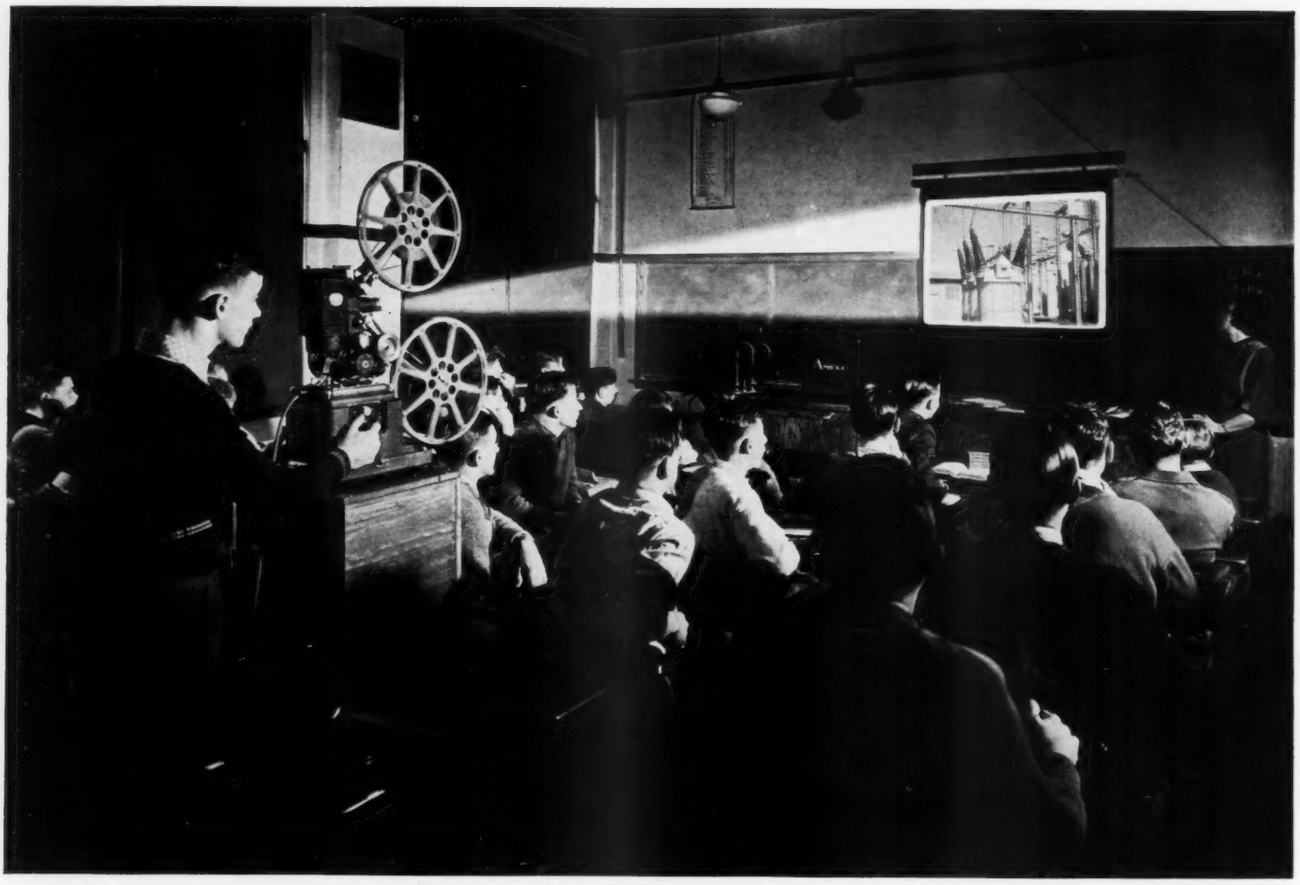
When science and industry were still in the elementary stage, inventions were relatively simple. But today most of the important inventions and discoveries require the combined efforts of a number of specialists, extensive experiments, and laboratories equipped with expensive apparatus. Teamwork sponsored by corporations has largely supplanted individual effort.

Millions are spent on research, much of which is fruitless. Whatever invention may result must first be developed as a commercial product. Usually tremendous sales promotion expenses are incurred before the patented product begins to pay. Often it never brings in a profit. In such cases all the expenses involved must be written off as a total loss. But if the invention is a success, those who buy and benefit from the new invention pay the bill and a profit to the owners of the patent, through the simple expedient of maintaining a high price for the product, if conditions permit. And that is as it should be.

Of course there are many ramifications. The successful invention may have cost little or nothing to develop—just a stroke of luck—and yet the corporation charges a high price for the product. But whatever the particular circumstances were, the fact remains that the cost of invention must be paid, and the aggressive corporation that promotes it must be assured an opportunity to make a disproportionately large profit for a limited time in return for the risks involved. Without patent protection and the possibility of such large profits on new inventions, there would be no incentive to put forth the effort and risk the money.

Even if legislation for the price regulation of patented products should be enacted, it would be impossible to enforce such legislation without defeating its purpose. The "larger corporations" at which such legislation would be aimed would be the very ones to benefit, and at the expense of the small companies. The larger corporations could absorb the research and patent promotion costs in the selling price of their established products. Small companies with only a few products could not do this and, therefore, with no prospect for big profits, would have to forego extensive research activities.

And who is to determine the "fair price" for a patented product? On what basis would it be determined? And why should a genius be compelled to offer the public the benefits of his new creation at a dictated price? If for a period of seventeen years, the advantages of a particular progress of science are withheld from the public, what of it? The "public" got along without it for millions of years; why not a few years longer? Suppose the inventor had never been born or had kept his invention a secret? Regardless of all arguments it must be remembered that without promise of profit there can be no progress.



In the Ampro projector speed is controlled by a rheostat when showing silent pictures. For showing sound pictures, rheostat is cut out and governor controls speed, holding it constant

UNIVERSAL MOTORS

Their Selection and Application

Torque, speed and efficiency curves, speed control methods, effects of reduction gears and other features of universal motors, as explained by engineers of The Dumore Company

BRIEFLY SUMMARIZED, the outstanding features of motors of the universal type are that they are small; can operate on any frequency from 0 to 60 or more; can be wound for voltages from 32 to 250; and can run at speeds as high as 20,000 r.p.m. The field of application is limited primarily by their maximum power rating which is about ¾ hp. But they deliver high horsepower for their size; a ¾ hp. universal motor weighs only 13¾ lbs. and can be packed in a 9½x6 in. box.

Maximum efficiencies occur at speeds of 6,500 to 8,500 r.p.m. However, universal motors can be wound for full-load speeds of 3,000 to 10,000 r.p.m. and have been wound for speeds up to 15,000 r.p.m. for special purposes.

The universal series motor has a high starting torque. Reference to the curves in Fig. 1 shows that this averages three to four times the full-load torque, that is, the torque at maximum efficiency.

Because this motor can run on either a.c. or d.c. currents of the same voltage it is unnecessary to provide a special design of motor for each community where electrical conditions may differ. This also applies to its use in industrial plants that have both types of current.

With reference to the power factor of the universal motor, it is approximately 85 to 90 per cent at full-load speed, as shown by the curves in Fig. 2 which are typical.

This motor occupies less space and weighs less than the equivalent-horsepower induction motor, primarily because it delivers its power at much higher speeds. The induction motor speed limit on 60 cycles is approximately 3,600 r.p.m. In the universal motor the same power is obtained in a smaller space because power is proportional to the product of torque and speed, and the speed may be 1½ to 10 times higher than that of an induction motor. For low speed and constant speed drives, speed reducers and governor controls have been devised for use with universal motors and now can be purchased as standard parts from the motor manufacturer. In Fig. 3 are shown the

weights of direct drive and geared universal motors of various horsepowers.

Some of the factors which must be studied when considering a universal motor, include:

1. Efficiencies of this type of motor are low when compared to those of larger motors of other types, averaging approximately 50 per cent at full-load. However, this is not a serious factor in the types of applications for which small motors are generally used.

2. The speed of a universal motor varies with the load, voltage and the amount of friction, which last will differ for various conditions. Age and wear will change the speed characteristics but if the motor is carefully selected for the duties imposed this speed variation probably will not be a handicap.

3. Being a series motor, the speed theoretically will rise to infinity at no loads. Actually this is not a serious problem because windage and friction usually limit the speed to a safe figure.

4. The necessity of servicing brushes and commutator tends to limit the use of this motor to intermittent duties. Where operating conditions are favorable and loads light, continuous duty applications have been successful.

5. Characteristics of operation are different on a.c. and d.c. current. Because of the increased impedance of windings on a.c., the horsepower output is less for a given speed. If this is important a resistance can be introduced to reduce the speed when d.c. is used.

The accompanying curves, Figs. 1, 2 and 4, based on tests of a standard type K Dumore universal motor indicate the general performance of this type of motor. As may be seen, current, wattage and torque vary approximately inversely as the speed—as the load increases the speed decreases.

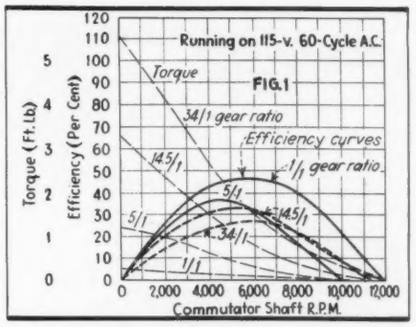


Fig. 1—Torque and efficiency curves of universal motors with various ratios of gear reducers

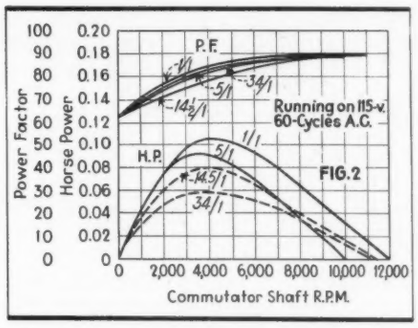


Fig. 2—Power factors and horsepower curves of universal motors with various ratios of gear reducers

It will be noted that the universal characteristic is limited by the speed. That is, below full-load speed the similarity with a.c. and d.c. performance disappears. This is because of the increased inductive reactance voltage drop on a.c. caused by the increased current. Universality is also limited by voltage,

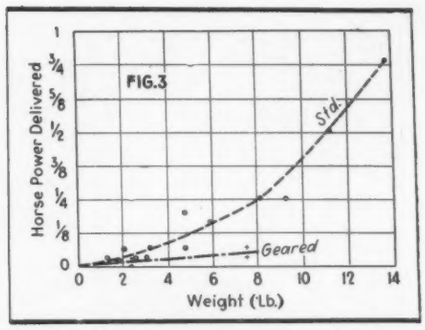


Fig. 3—Approximate weights of direct drive and geared universal motors of different horsepowers

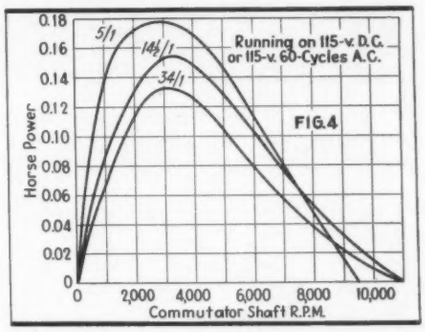


Fig. 4—Torque and horsepower curves of universal motors with various ratios of gear reducers

frequency and size. The a.c. and d.c. performance are nearly identical in the voltage range of 32 to 230, the frequency range of 0 to 60 cycles, and the size range up to ¾ hp. However, the operation of small universal motors on 230 volts d.c. is not usually recommended because of the difficulty of providing enough clearance and of securing efficient crawl distance to avoid flashovers in compact housings.

The mechanical designer who expects the best of assistance from the motor designer in solving his problem must be prepared to give as much cooperation and furnish as many design details as possible. For that reason he should provide the motor manufacturers with the following facts:

1. Speed. The standard universal motor as purchased "from the shelf" operates at maximum efficiency and horsepower at from 4,000 to 9,000 r.p.m. The actual full-load speed may be plus or minus ten per cent of the standard rating and some thought must be given as to whether or not this will impair the operation of the driven machine. If a closer rating is desired a governor control can be used to limit the motor to a desired maximum speed with a plus or minus ½ per cent variation.

If a lower speed is desired, plus the other qualifications of a universal motor, a speed reducer can be incorporated. Again it will be necessary to introduce a governor control if a speed variation within plus or minus ½ per cent is re-

Fig. 5—Business districts may have a.c. of 25 or 60 cycles or d.c. Universal motor permits installation of these photograph machines anywhere

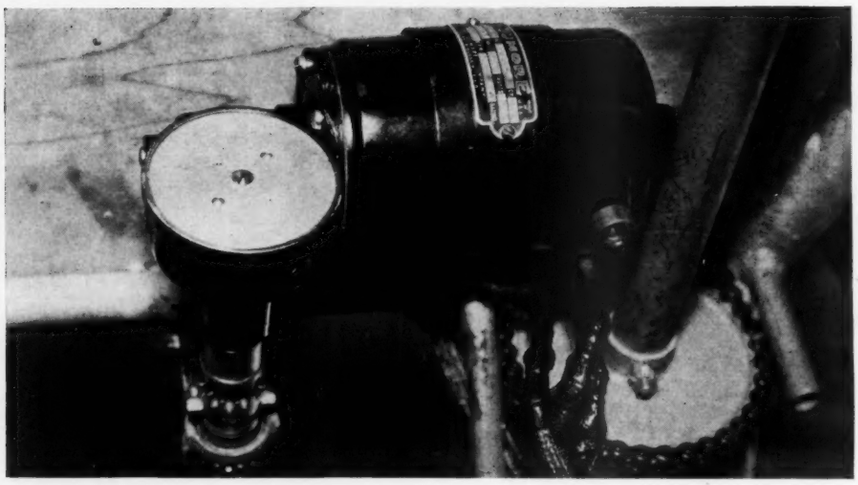


Fig. 6—Weight being an all important factor in aircraft construction, the landing gear on the new Beechcraft, Model 18, is retracted by geared universal motors. In addition to desired light weight, motor must operate on 12 volts d.c.

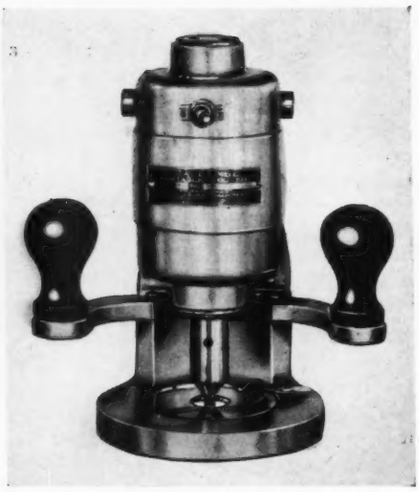


Fig. 7—Small size, light weight and high-operating speed make the universal motor ideal for hand tool applications

quired. All of these combinations are available.

Another possibility is to introduce a resistance which will control the speed. This may take the form of a series resistance or rheostat or a shunt resistor across the armature as shown in Fig. 8. Or a combination of the two, known as potentiometer control, may be used. The series rheostat, although providing infinite variation from zero to full-load speed, increases the amount of speed fluctuation caused by changes in voltage and slight fluctuations in load. The shunt resistor tends to limit the high idling speed of the universal motor, being adjustable over a limited range from the maximum no-load speed to somewhat above the full-load speed. The speed is more stable with this arrangement. The potentiometer circuit combines the wide range of the series with the flat speed characteristic of the shunt resistor. When designing a machine incorporating a rheostat-controlled motor, thought must be given to mounting of the rheostat and proper dissipation of the heat it generates. Overheating of the field coils must be prevented by using a sufficiently high resistance.

When a decision is being made as to the comparative merits of a universal motor plus a gear reduction or a rheostat it must be remembered that the resistance itself may take up considerable space. For example, a ¼ hp. universal motor may require 3 to 4 amp. capacity resistance and this amount of resistance is of no small size.

2. Power. The most important consideration in most cases is the amount of load the motor must handle. Normally a universal motor is purchased primarily for its speed characteristics and not necessarily for its load characteristics. However, when the amount of load the motor must handle is the most important consideration, torque is the best measurement of the capacity of the motor. For instance, at very low speed a motor may deliver 1.5 lb.-ft. of torque and yet be rated at only 1/600 hp. In giving the power required in a geared motor the specifications should state whether the power is that developed at the motor shaft or at the gear output shaft.

3. Duty. Because motor ratings depend upon the heating of the windings, and since the heating depends in part upon the duty—that is, the length of time the motor is operated without a rest—it is important that the duty for which the motor is intended be specified. Continuous operation is usually considered 2½ hr. or longer, intermittent duty may be 1 hr. that is, 60 min. off, 60 min. on, or 30 min. on, 30 min. off and so on. N.E.M.A. standards require a 40 deg. C. maximum rise in temperature at full-load speed. Induction motors have a safety factor with regard to this horsepower-temperature requirement which universal series motors do not have.

4. Direction of Rotation. The rotation of a universal motor is determined by the commutator setting and the field connections and must therefore be specified. Although there is no standard, several manufacturers identify direction of rotation from the commutator end, regardless of the location of the shaft extension. Counter-clockwise or three-, four-, or six leads reversible motors may be had on special order. Reversible motors with four or six leads are to be preferred from the standpoint of electric balance, since they utilize both field coils for both directions.

The universal motor is not inherently reversible but can be made so on special order. It is not as efficient as an unidirectional motor and at the maximum has only about 80 per cent of the power. In the 1/10 hp. or larger motors connected for reversing service, good commutation can be secured only in one direction. It will be poor in the other direction because it is not possible in practice always to set the commutator exactly on the mid-point between the two neutral zones. Brush life is also reduced when a motor is made reversible.

Universal motors are available with worm gear or spur gear speed reducers. Speeds ranging from 5 to 4,000 r.p.m. can be obtained. The number of gear ratios usually carried in stock makes it possible to use a direct drive in most designs. They provide a compact, grease-tight unit complete and ready for coupling to the drive shaft.

Certain advantages for the geared universal motor over the induction motor are: High starting torque, a.c. and d.c. operation, small size and light weight per horsepower. For example a standard universal motor with a 5 to 1 ratio has about the same full-load speed as a 6-pole induction motor. Other standard universal types with 4½ to 1 ratio correspond roughly to a 4-pole induction motor and with a 2 5/8-1 ratio to a 2-pole induction motor. In addition the universal motor lends itself more readily to speed variation than does the induction motor.

In single reduction and the first stage of double reduction worm gearing where high speed is likely to create noise a laminated plastic gear is often used with the hardened steel worm. In the second step of the double reduction where high torque transmission is important and noise caused by speed does not exist, metallic gears are used in conjunction with the hardened steel worm. Spur gearing generally employs metallic gears.

Generally speed reducer motors are

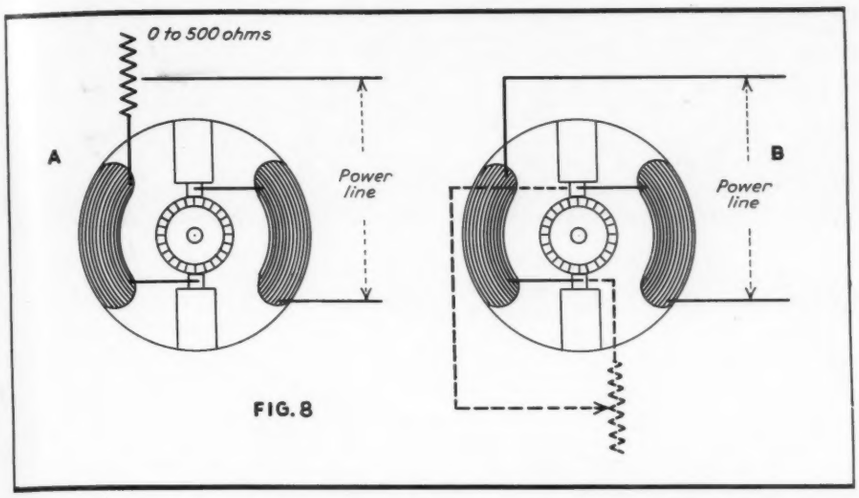


Fig. 8—(A) Speed control through a variable resistance in series with the field gives a wide range but reduces starting torque. (B) Speed control through a variable resistance shunted across the armature increases starting torque

not recommended for continuous duty at their rated output. On lesser loads they may be operated for longer periods of time. In selecting a geared motor for an application, the nature of the load and its effect on the gears should be kept in mind. Gears will not stand up forever under such abuse as repeated stalls, "hunting" caused by the fly-wheel effect of high inertia loads, or the recurrence of the high point in a varying load cycle at the same tooth.

Some motor housings are arranged to hold the speed reducer unit in any position at regular angular intervals around the full circle. The ideal position is with the worm or pinion at the upper level because the grease is not subjected to churning by the high-speed worm.

Depending on the space available, which controls the center distances of the worm and the worm-wheel, there are certain definite limits on the most efficient method of getting speed reduction. In certain installations spur or bevel gears are preferable to worm gears even though they are more noisy.

Considerable trouble has been experienced in the problem of lubrication. Many methods of oiling or greasing the motor bearings are available and motor designers are prepared to furnish motors for the most rigid lubrication requirements. For that reason it is necessary to know the temperatures at which the motor is to be operated. For example, one of the difficult problems to solve was that of supplying a properly lubricated motor drive for retractable landing gears in aircraft. Here, the probable wide temperature variation requires particular care in the design of the lubricating system of the drive.

In view of the fact that the designer is using a compact low horsepower device he should not be satisfied unless he uses the most efficient type of drive. Efficiency curve for gear reduction units are given in Fig. 9, showing the wide range over which the efficiency varies. The required watts input can be reduced materially by proper drive design. The efficiency of the design in reducing friction may determine whether a light compact universal motor can be used or whether recourse to some larger power unit may be necessary.

A factor which will serve to improve the design involving a geared motor is to provide a mounting as close to the gear shaft extension as possible. Rigidity between mounting point and output shaft will eliminate much misalignment and consequent increased gear wear.

Since voltage conditions vary from place to place it is necessary that the conditions under which a motor must operate be known. While the standard motor is wound for 115 volts it is not at all uncommon to find that it is being required to operate at anywhere from 100 to 130 volts. Motors built according to N.E.M.A. standards will operate satisfactorily on line voltages ten per cent above or below rated voltage but not necessarily in accordance with their ratings. Proper engineering will avoid the improper operation of the product.

As is true for other types, motor manufacturers are prepared to supply the necessary universal motor parts so that they can be built into a machine which is in process of design or construction. Again it is necessary that the mechanical designer and the electrical designer work together from the beginning to achieve maximum efficiency.

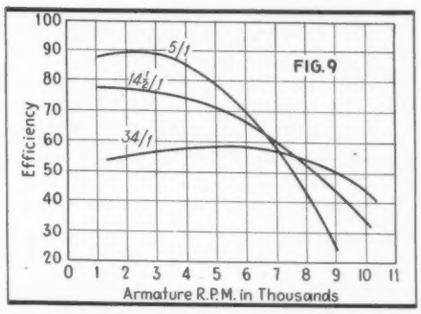


Fig. 9—Efficiency curves for three gear reduction units of different ratios but gear center distance the same for all units

Typical Universal Motor Ratings and Dimensions

Horsepower Output		*Input in Watts*		*RPM of Loaded Shaft at full load*	*Weight in lb.*	*Length overall in in.*	*Diam. of case in in.*	*Duty*
a.c.	d.c.	a.c.	d.c.	a.c./d.c.				
Standard								
3/4	3/4	890	975	7500/7000	13 3/4	9 3/16	5 1/2	Const.
1/2	1/2	705	725	8500/8000	11 1/5	8 11/16	5	Const.
1/4	2/5	370	460	5000	9 1/5	8 11/16	4 3/8	Const.
1/4	3/8	410	480	5500	8 1/8	7 13/16	4 1/2	Const.
1/5	1/4	290	300	7000/6500	4 3/4	7 1/4	3 1/2	Const.
1/6	1/5	245	270	5000/5500	5 7/8	6 3/4	3 1/2	Const.
1/15	1/10	108	130	6000	4 3/4	5 5/8	3 3/8	Const.
1/15	1/10	108	130	6000	3 1/4	5 11/16	3 3/8	Const.
1/16	1/15	85	97	8500	2	5 3/16	2 11/16	Const.
1/30	1/23	70	80	7000	1 1/4	4 11/16	2 11/16	Const.
1/30	1/20	69	96	7000/6000	3	4 7/8	3 3/8	Const.
1/30	1/20	69	96	7000/6000	2 1/2	4 15/16	3 3/8	Const.
1/50	1/38	41.5	48	6500/7500	1 3/4	4 3/4	2 13/32	30 min.
1/50	1/33	46.5	59	5000/6500	1 3/4	4 3/4	2 13/32	Const.
Geared								
1/15–1/27	1/9–1/20	160–138	182–159	1200–200	7 1/2	8 3/32	3 1/2	Const.
1/31–1/64	1/23–1/49	70	77	3810–250	2 3/8	6 1/4	2 11/16	Int.
1/41–1/66	1/29–1/52	62	66	2050–200	1 15/16	5 3/4	2 11/16	Int.
1/42–1/61	1/36–1/55	69	66	3810–250	4 3/4	6 11/16	3 3/8	Int.
1/49–1/75	1/42–1/69	58	62	3810–250	3 5/8	5 15/16	3 3/8	Int.
1/146–1/478	1/82–1/345	43	53	111.1–7.4	3 7/16	4 31/32	3 3/8	30m.

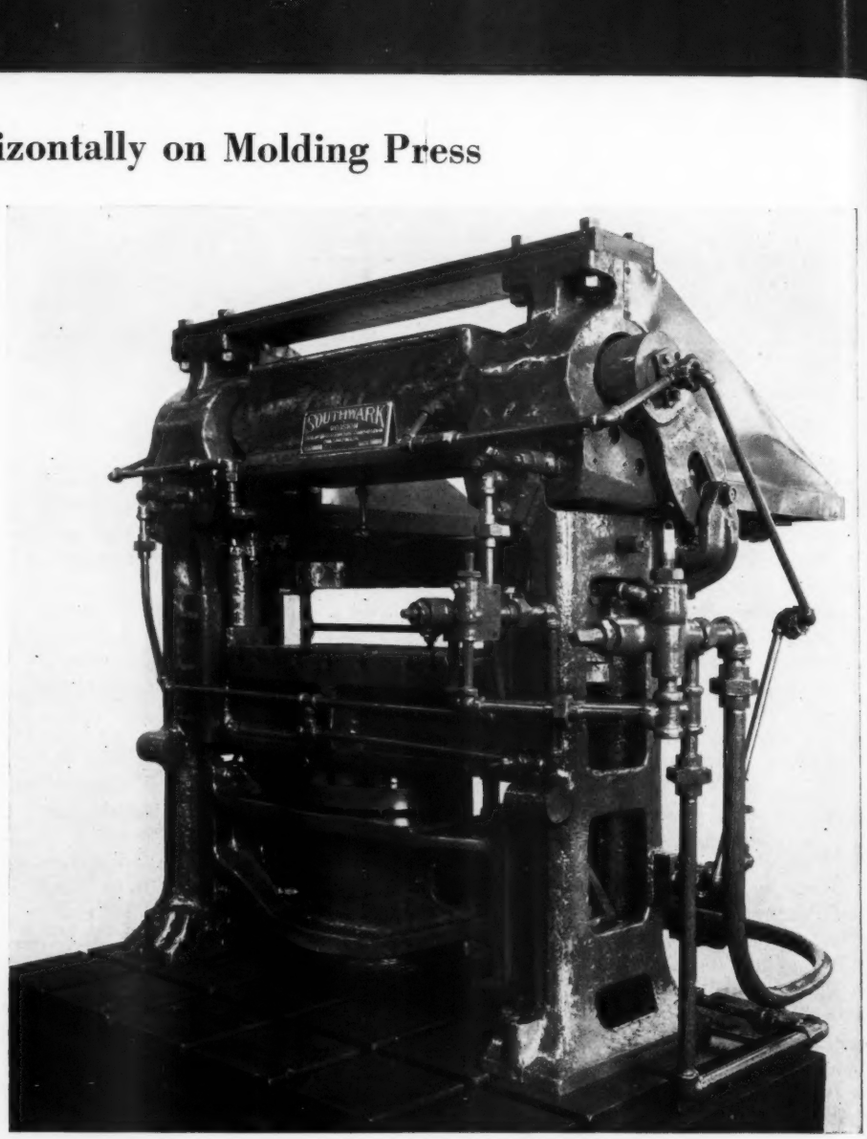
Modern Designs

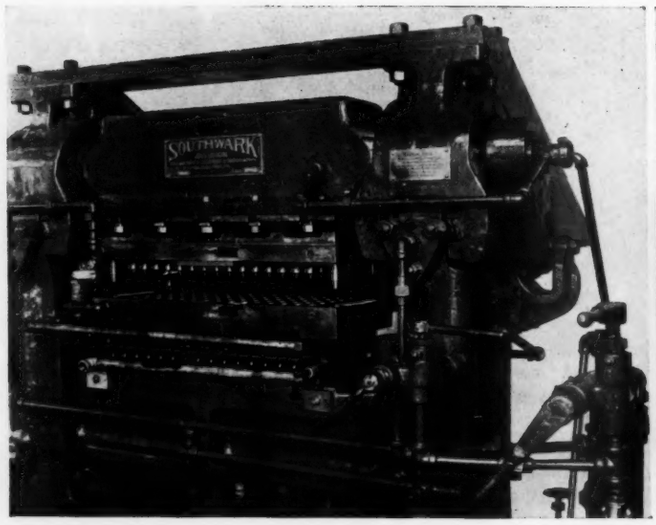
Tilting Head Moves Horizontally on Molding Press

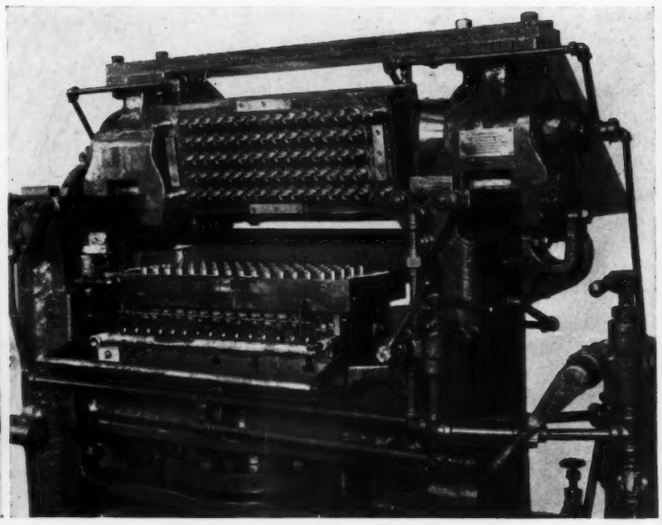
Pivoted on trunnions supported in side castings which slide horizontally on the side frames, the top platen of new molding press developed by Baldwin-Southwark is rotated through an arc of 90 deg. so that both halves of the mold are exposed for cleaning, placing inserts, filling and removal of the molded pieces.

Hydraulic pistons at top of side frames push and pull the sliding units into open and molding positions over bearings lined with bronze gibs to compensate for wear. On the trunnion ends which project beyond the bearings are fastened dogs with radial slots that engage fixed rollers supported in side frame brackets so that head receives a rotary motion of 90 deg. as side castings are moved along slide.

A single vertical ram moves the lower platen up for the molding operation. Hydraulic bronze pushback cylinders with stainless steel rams for returning the lower platen to its bottom position are carried in the side frames of the press. To insure parallel surfaces between the two halves of the mold the bottom moving platen is guided at the corners in the side frames.

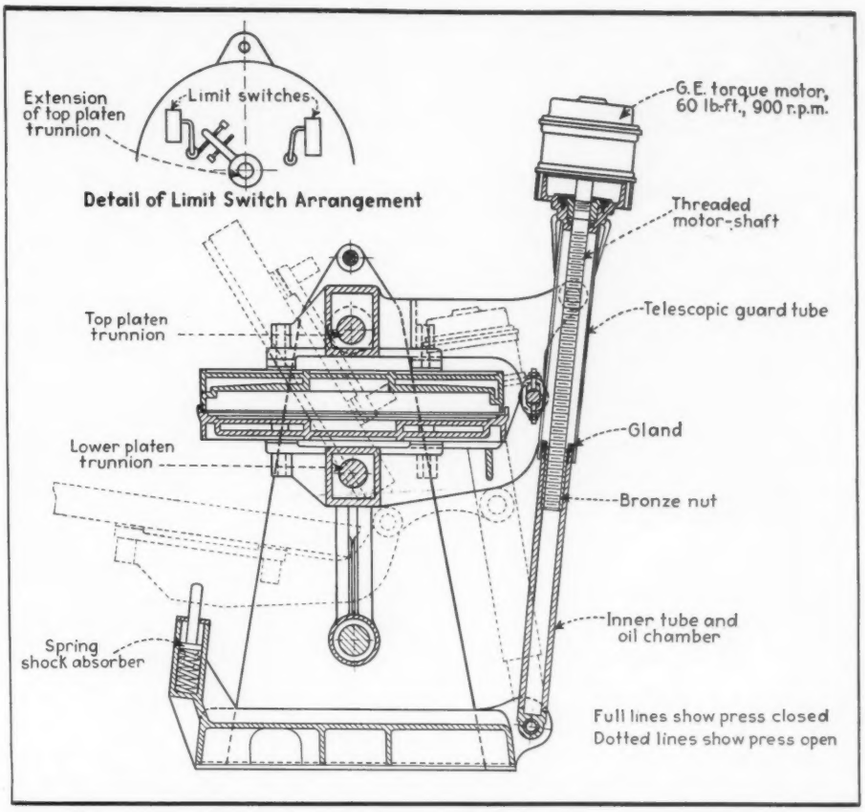


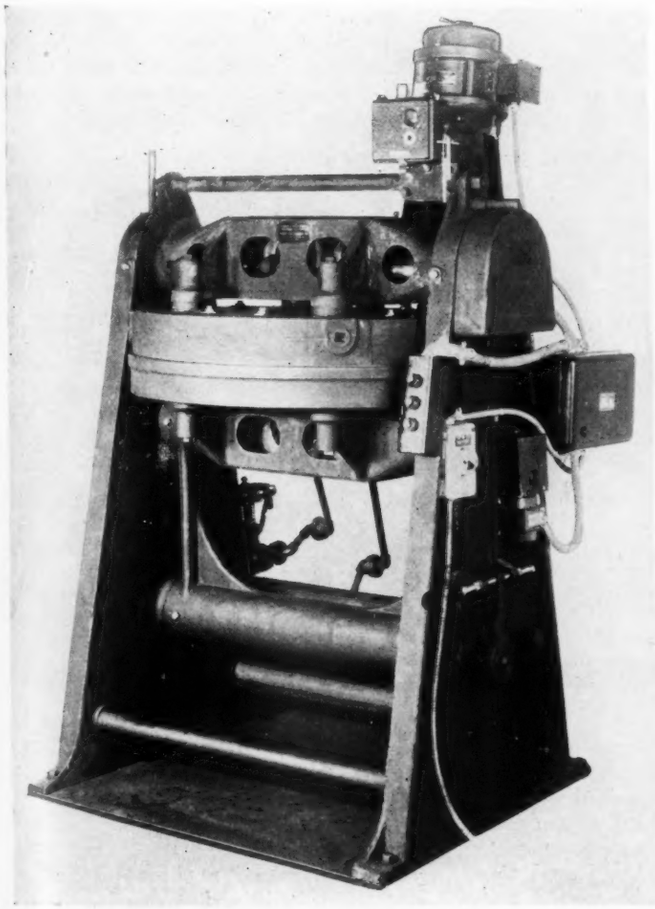


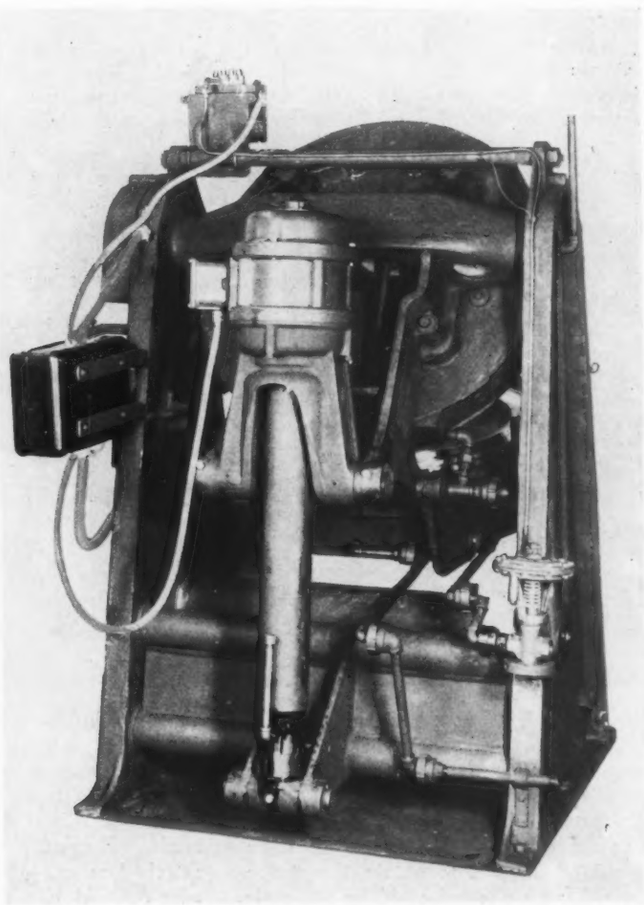


Screw on Motor Shaft Opens and Closes Press

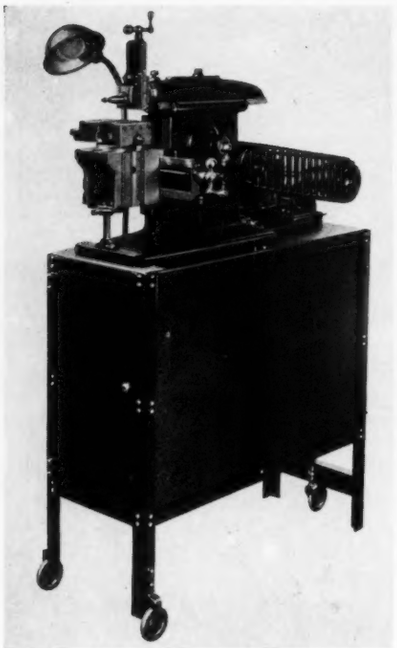
Motor mounted on casting at end of telescopic tube has an extended shaft on which screw threads are cut. These turn in a bronze nut held fixed in the end of inner tube. This tire vulcanizing press was developed by National Rubber Machinery Company. The inner tube also serves as an oil chamber in which the screw is lubricated at every cycle. The motor has a rating of 60 ft. lb., has a speed of 900 r.p.m., reverses once every cycle and operates intermittently. Limit switches on one end of top platen-trunnion stop motor at the open and closed platen positions. Manual control of motor is accomplished with a three button magnetically operated switch. Steam for vulcanizing is conveyed to the press platens through piping connected with swing joints. A pressure controlled electrical cut out circuit prevents magnetic switch from functioning when steam pressure and consequently temperature is down below that required for vulcanizing.

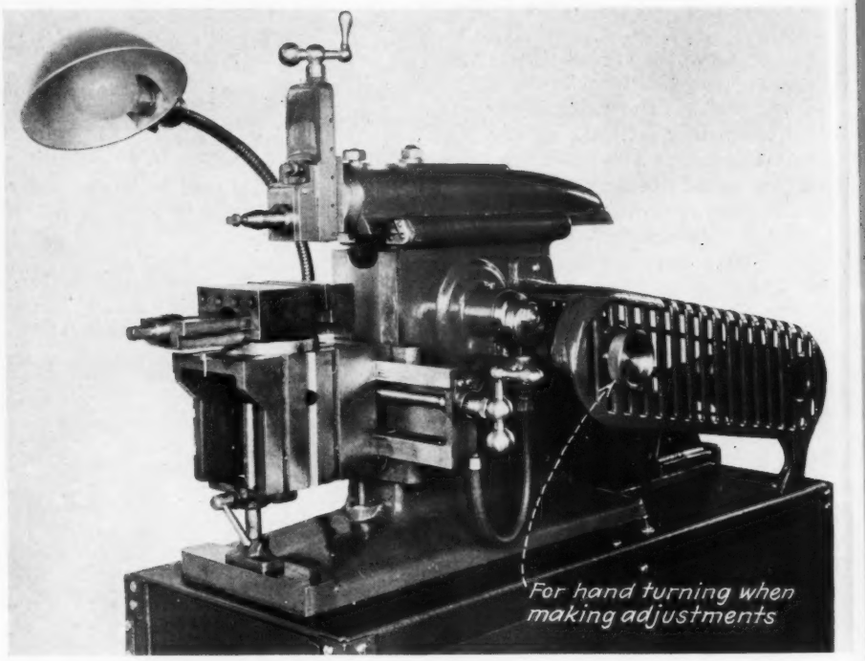






Modern Designs—Drives Feature Design of Small Shaper

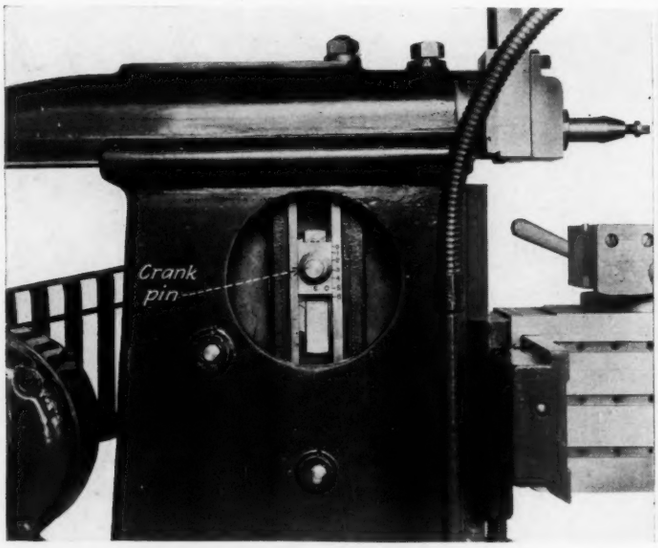


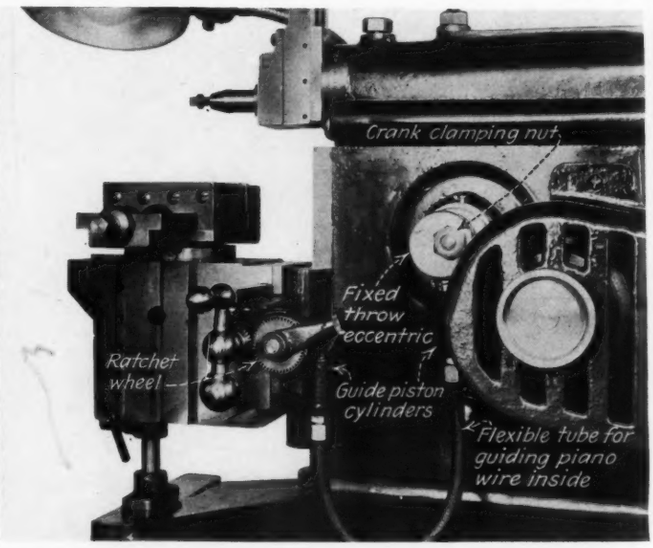


Accuracy of operation, quality features and low price were aimed at in the Ammco 6-in. crank shaper designed by the engineers of the Automotive Maintenance Machinery Company. Portable model shown here is driven by a ¼ or 1/3 hp. motor through a flat belt to a countershaft with a 3-step cone driving pulley, then to main shaft of the shaper. Pinion of SAE 1045 steel meshes with helical cut Bakelite gear.

Total weight of the shaper is 300 lb., including countershaft and motor mounting, motor and cabinet. Mounted on three 4-in. diam. casters, one swivelling, the machine is readily rolled from place to place. Swivel caster can be raised to permit bench legs to rest solidly on the floor. Motor on pivoted spring-cushioned base automatically adjusts tension in flat-belt drive to countershaft. Screw adjustment permits moving countershaft mounting to give desired belt tension in drive to main shaft.

Helical spur gear pinion of SAE 1045 steel, heat-treated drives gear made of molded Bakelite for silent operation. Main drive shaft is of SAE 1045, and ground all over. Bearings are all phosphor bronze. Crank pin is of chrome-vanadium steel. Knurled knob is to turn machine by hand when adjusting crank mechanism to stroke desired.

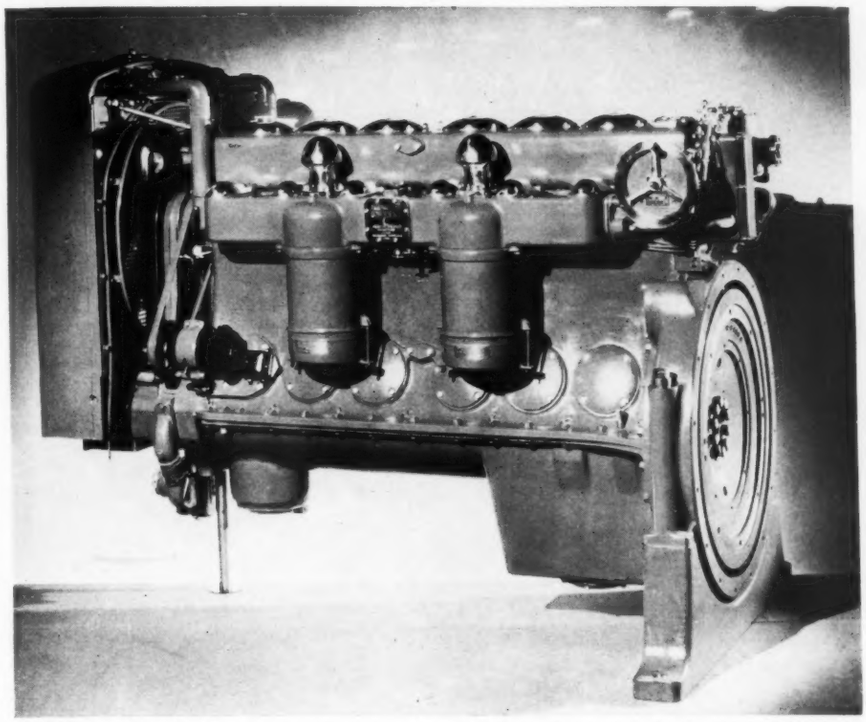




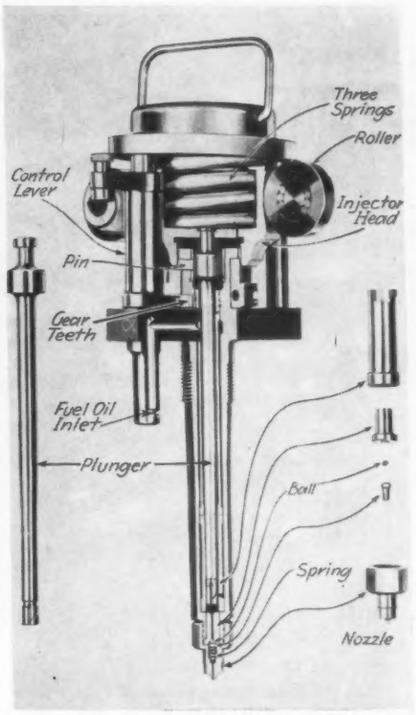
Stroke adjustment is made easily. After turning machine by hand to bring crank in uppermost position as shown here, the crank locking nut shown in illustration to the right is loosened. The cam or eccentric block can then be raised or lowered to obtain the stroke desired, which is indicated by the scale inscribed in the rocker arm. The clamping nut is then tightened and the machine is ready to run.

Automatic cross feed is driven by a fixed eccentric at the end of the crankshaft. Eccentric drives guide piston attached to end of a heavy steel piano wire encased in a flexible metallic tube. Other end of piano wire is attached to a similar guide piston which oscillates pawl. More or fewer teeth in ratchet wheel can be uncovered, thereby changing feeds in increments of 0.003 in. from 0.003 in. to 0.015 in. By pulling pawl knob and turning it at about right angles automatic feed is disengaged entirely.

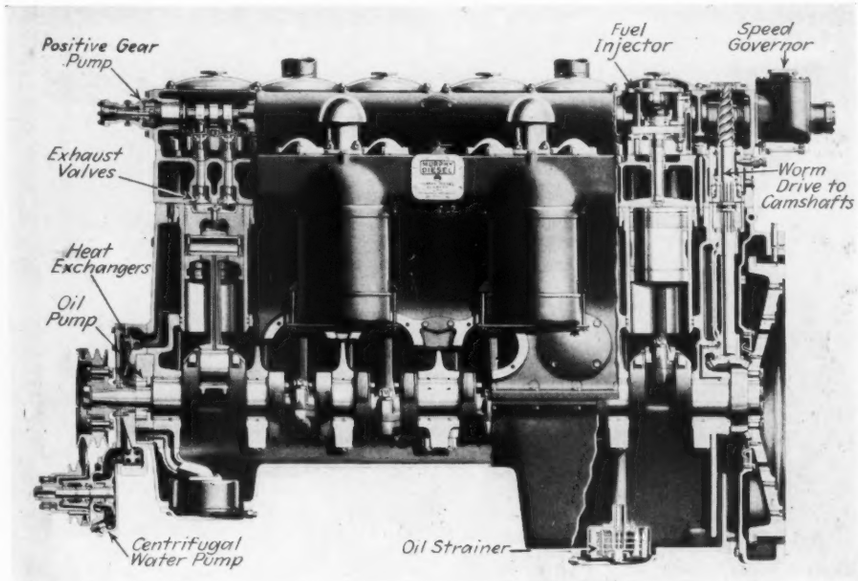
Modern Designs—No High-Pressure Fuel Lines in Diesel



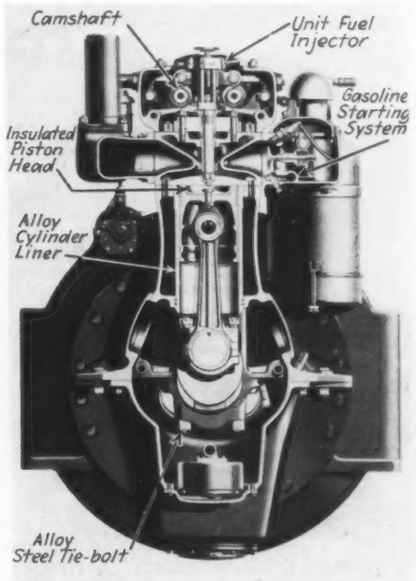
Filtered Fuel is supplied at low pressure to within an inch of nozzle tips, the injector meters and injects the fuel directly into combustion chamber, in the new Murphy diesel engines. Each cylinder has its own fuel injector mounted between the two camshafts. One wheel controls both the throttle and the gasoline starting mechanism. An oil. On down stroke the trapped fuel is matically stops the engine if lubricating oil pressure fails. The top of the pistons are shielded from the heat of combustion with metal alloy insulating cups.



Cams Force Plunger upward against three compression springs, the space below the end of plunger filling with fuel oil. On down stroke the trapped fuel is forced through ball check valve, through the drilled nozzle tip and then directly into combustion chamber.

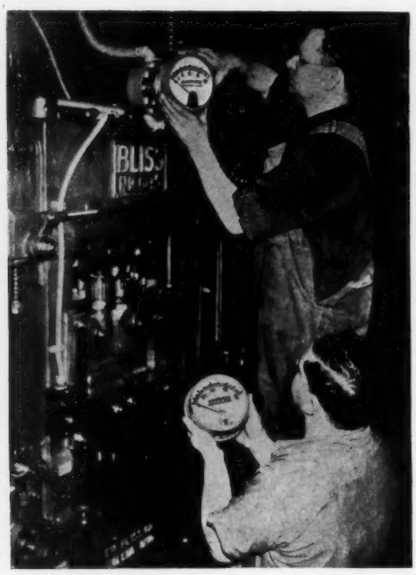


Positive Gear Pump supplies fuel to all injectors and excess is returned to tank. Four valves in each cylinder are grouped symmetrically around central fuel injector. Exhaust valves have shrouds to protect valve stems. Double springs are used on each valve. Gear oil pump forces oil through heat exchanger to all parts of engine. Crankshaft is mounted in seven steel-backed copper-lead lined bearings. Ball bearing mounted hardened steel worm drives overhead camshafts through two bronze worm gears. Hardened steel coupling allows for misalignment and cylinder-head gasket compression.

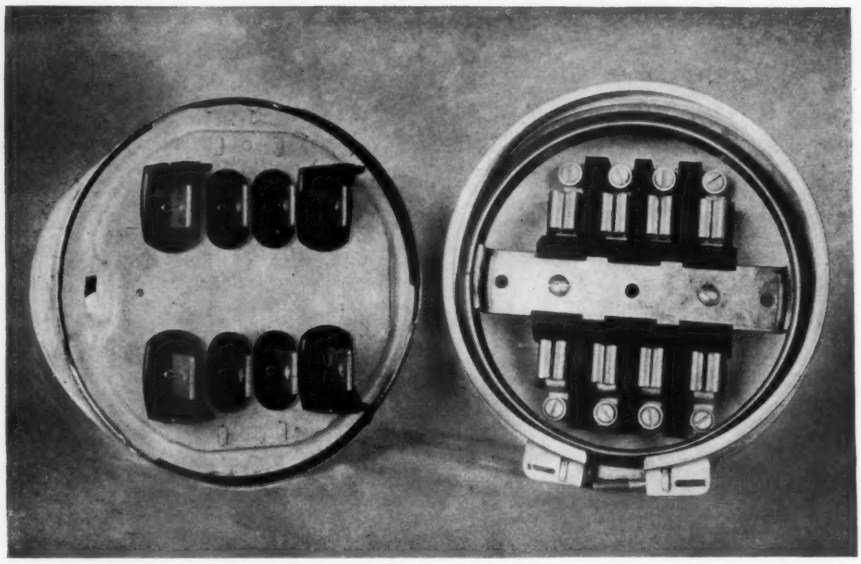


Gasoline Starting System, built into inlet manifold assembly, does not affect normal diesel operation. Alloy steel tie-bolts extending from top of cylinder head to bottom of crankshaft bearing caps relieve crankcase of stresses. Replaceable cylinder liners are water-jacketed entire length.

Modern Designs —Plug-In Electrical Instruments for Machinery

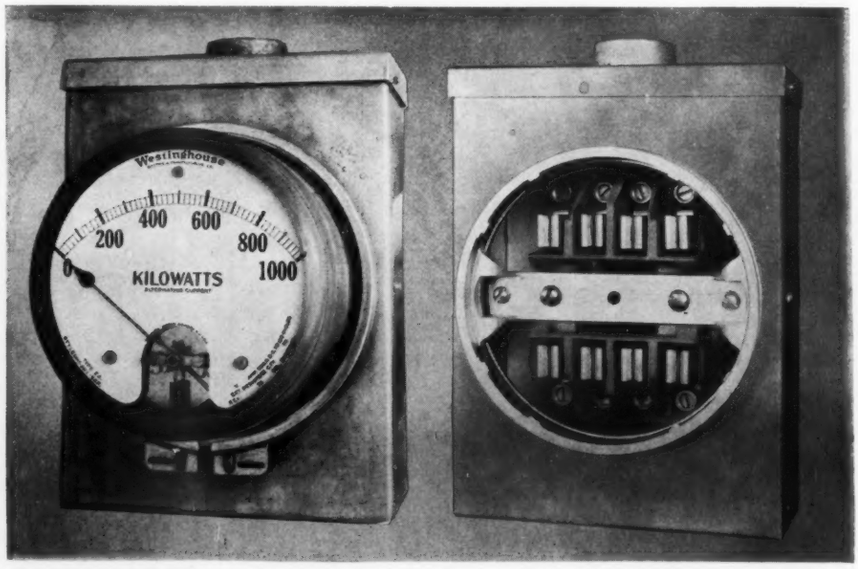


Simple box provides structure for installing socket that supports plugged-in instrument and has space for permanent wiring. With this new arrangement developed by Westinghouse Electric & Mfg. Co., no panel or rear stud connections are needed. Instruments can be readily replaced by one of different capacity or by one to measure another electrical quantity, they can also easily be moved from one circuit location to another.



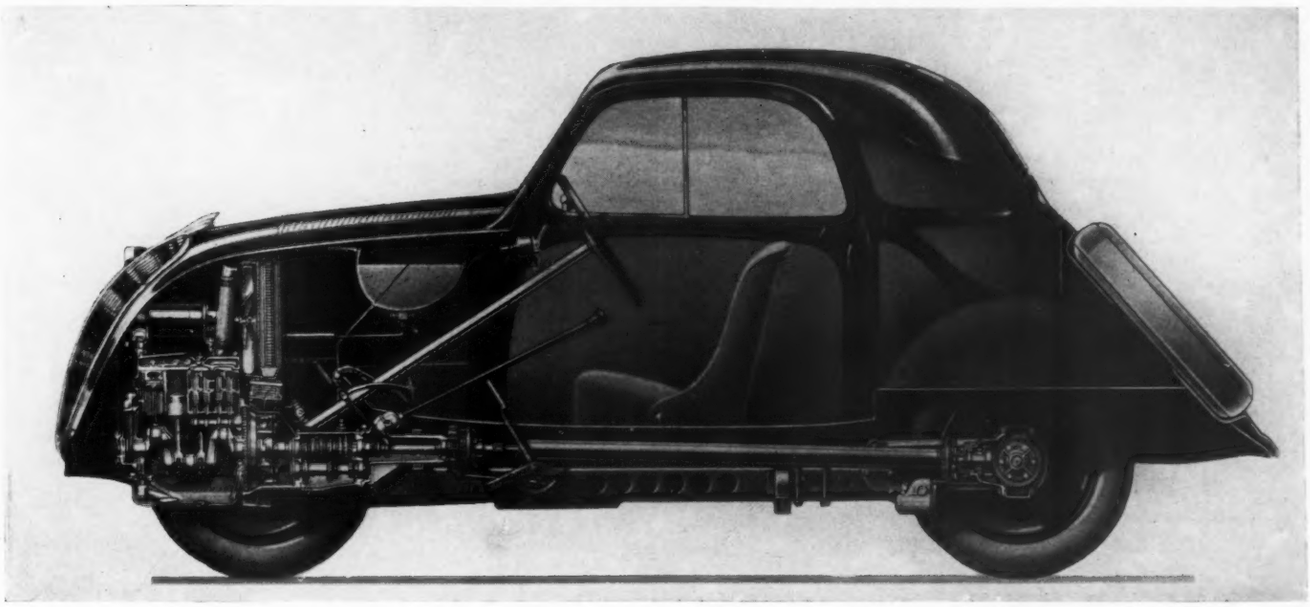
Internal adapter plate made of steel serves as a base for mounting the measuring element which is identical with that used in the corresponding switchboard instruments. At the rear of the plate are switch blade type terminals insulated from the base with molded composition angle pieces which guide the blades into the contact jaws of the socket when plugging-in. A sheet-brass clamping ring holds the instrument securely and also holds the clear molded glass cover to the base plate. The ring has a bayonet joint which engages lugs on the base plate and is fastened in place with a twisting motion, sealing and protecting the assembly from weather. The base, cover, ring and measuring element comprise and complete the instrument proper. Sockets with circuit closing device can also be provided for connecting transformer type instruments.

Connected load horsepower of motor driven machinery is often more desirable for the operator to know than the amperes required for an operation or the kilowatts consumed. If wanted, ammeters and wattmeters with plug-in connections can be provided properly calibrated with scales or dials marked and graduated to indicate horsepower, to agree with the motor characteristics and performance.



Cases or boxes for the sockets are either round or rectangular in shape. The round forms are die castings with outlet lugs tapped for conduit connections. Single round boxes are used for 3-phase, 3-wire circuits for self-contained ammeters, voltmeters or watt meters. The rectangular types are made of sheet aluminum to which are attached die cast socket skeletons of the ring type. Single square boxes are employed for circuits and instruments requiring more than 5 terminal jaws. Two-unit and three-unit troughs are also made up for installing more than one instrument in one location. The die cast skeletons support the molded composition insulating terminal blocks on which are assembled the switch jaws and terminals for making the circuit and service connections to suit the instrument.

Modern Designs—Reversed Engine Adds Many Features

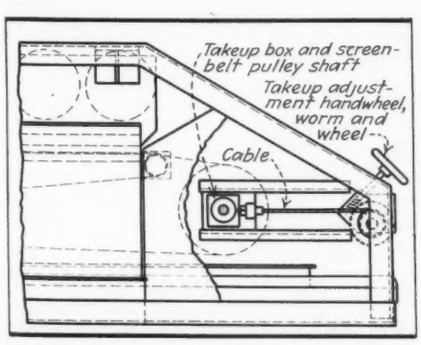


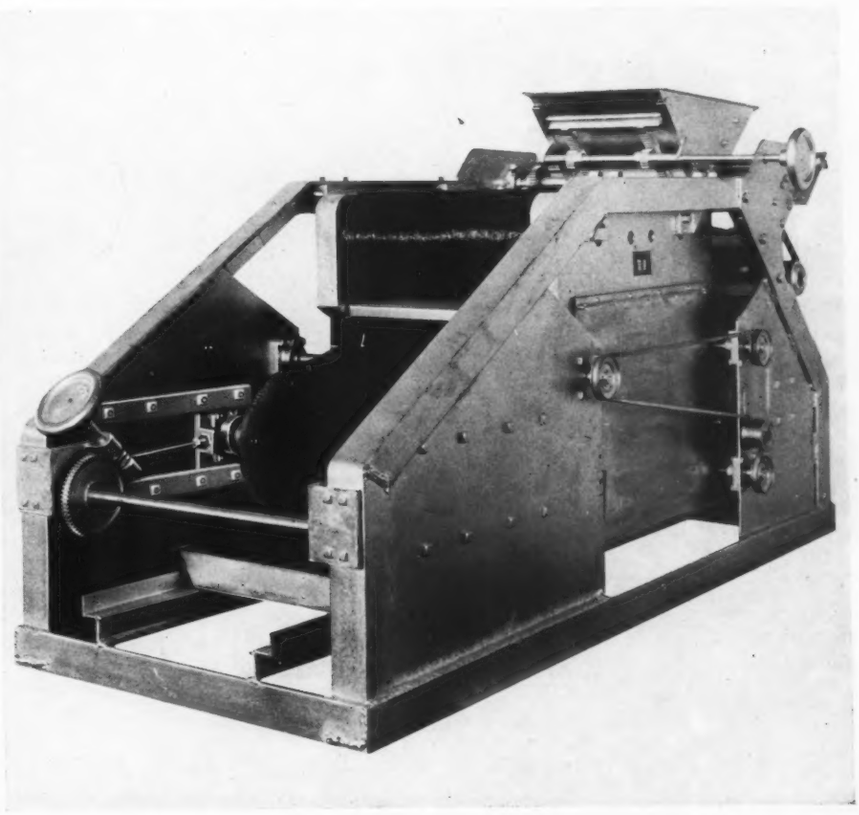
Turning the Engine end-for-end made possible many new features in the little Fiat "500" model. Putting the radiator and fan over the clutch gave room to move the engine forward, ahead of the front axle. This in turn increased the space available for passengers and luggage, and allowed putting the passenger seat almost exactly midway between the front and rear axles, a factor in easy riding.

With the engine reversed, it made it possible to slope the hood down over the engine, thereby increasing visability from the driver's seat and improving the looks of the car. Another feature is that the hood is hinged at the front lower end and thus can be swung down completely out of the way. The Fiat "500" has a 78¾ in. wheelbase and the transmission is low enough so that there is no hump or tunnel in the floor. It has been labelled by its manufacturers, "a miniature big car."

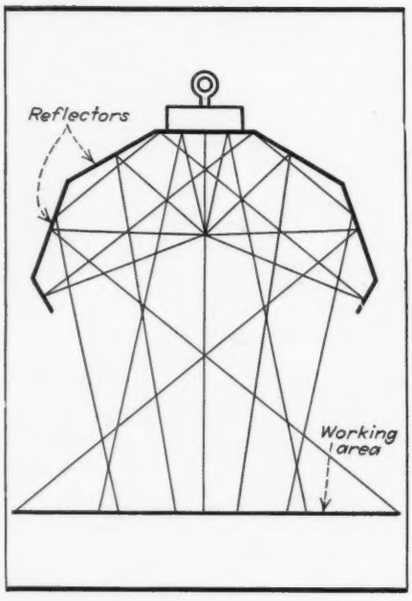
Maintains Belt Alignment With Tandem Cable Take-Ups

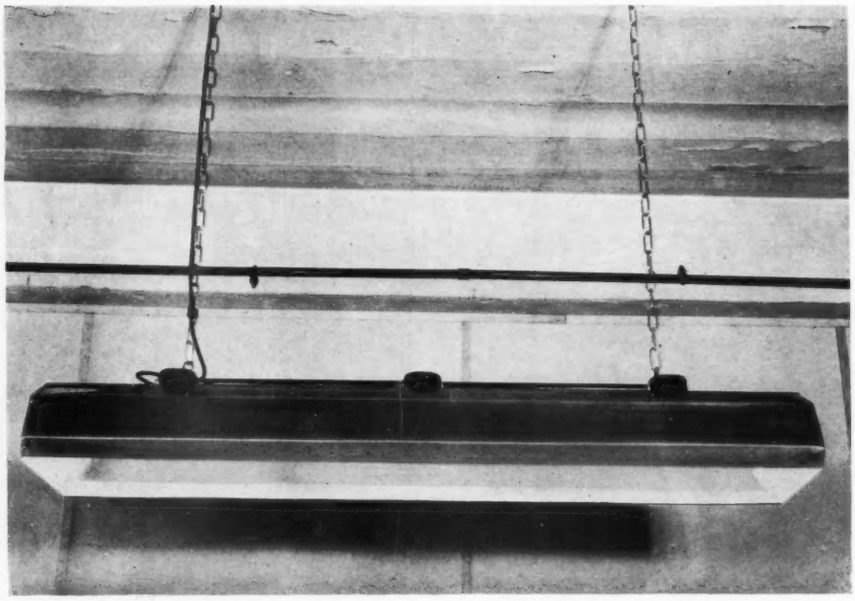
Take-up boxes on opposite sides of screen belt pulley shaft are adjusted uniformly and in unison by cable and pulley arrangement in new Stearns' magnetic separator. With this device the adjustable screen pulley shaft is kept parallel with fixed shafts in the machine and maintains alignment so that the vibrating screen belt will not crawl to either side as slack is taken up. The boxes slide in ways on the inside surfaces of the side frames. The two cable pulleys for winding up the cable are mounted on the opposite ends of a common shaft at the end of machine, keyed to this shaft is a wormwheel which is turned with a handwheel and worm.



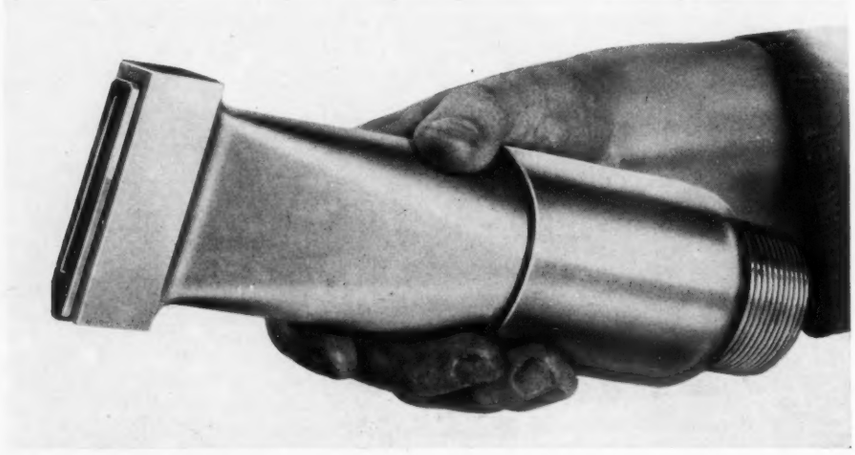


Modern Designs

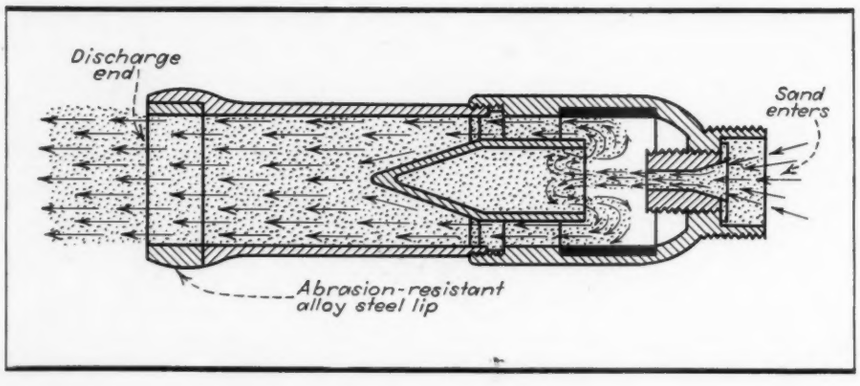




Reducing Losses that are inherent with many reflections, by a minimum redirection of light rays from source of illumination to area of working plane, is accomplished in the Orthoplane light, designed by United Cinephone Corporation, with a reflecting system made up of seven surfaces so arranged that their relative angles are calculated to give the least number of light path crossings inside the reflector. Most of the light reaches the working area in non-crossing convergent rays so that there is a minimum of shadow and absence of objectionable glare.



More Cutting Edges to impinge against the surface being prepared for finishing are produced by a baffle in chamber of sand gun which breaks down size of sand particles and gives them whirling motion. This new Michiana sand blast gun has a flattened orifice fitted with abrasion-resistant alloy steel lips, and operates at 80 to 100 lb. per sq. in. air pressure.



RANDOM JOTTINGS ABOUT NEW DEVELOPMENTS

Through the use of a flexible block mounted under three pliant rubber cylinders, the reciprocating sanding and rubbing machine manufactured by the Sterling Products Company is made to operate equally well on both curved and flat surfaces. Another design kink is the provision of a water connection and a series of openings on each side of the device, so that a spray is available for wet sanding.

Keotherizing is the term used by the American Hammered Piston Ring Division of the Koppers Company for its system of expanding pistons by the use of a blast of small steel shot. Piston diameters are increased from 0.005 to 0.012 in. by shot blasting the inner face. An air pressure of 60 to 80 lb. per sq. in. is used, depending upon size and thickness of the piston. This cold-working has the advantage of giving the body of the piston more spring than it had in its original state.

Malleable iron castings, made by Chicago Malleable Castings Company, are now used for street curbing. Advantages claimed include wider roadway possible and no jagged curbing such as caused by broken concrete. Made in 2-ft. sections, straight and curved, the castings are anchored into and backed by concrete. Malleable iron is used because of its toughness and corrosion resistance.

RESISTANCE WELDING

Principles and Design Data—II

L. H. FROST
Welding Engineer, Electric Controller & Mfg. Company

Charts and tables giving for different sheet thicknesses the size, spacing and strength of spot welds and the welder capacity required to make them. Part I appeared in January

IN THE types of machines described previously, the welding pressure is determined by the compression of a spring. Since pressures required vary from 100 to 1,000 lb., the springs are necessarily of heavy construction and are not easily calibrated. Considerable delay is involved when setting up the machine because of the necessity of trial and error methods. Modern machines are commonly supplied with a suitable scale to indicate pressure.

To provide an accurate and easily adjustable means for applying the desired welding pressure, the next development used air pressure to move the electrodes and hold them in contact with the work at the desired pressure. A design of such a machine is shown in Fig. 6. Regulating valves reduce the air line pressure to the desired operating pressure. The equalizing tank is used where there is considerable variation or fluctuation in line pressure.

Besides the standard types of floor mounting welding machines described previously, special types of machines are also available, such as the portable machine shown in Fig. 7. In this machine, commonly called a "gun welder," the necessary pressure and operation is obtained from an air cylinder. Several designs of this type of machine are available and they are used where the work is of such dimensions that floor mounted machines cannot be used, as in the spot welding of automobile bodies.

In addition to the above general types, machines of special design have been built for welding special alloys, for welding special shapes, and for making more than one weld in a single jig. An interesting development of a welder which makes a number of welds in succession

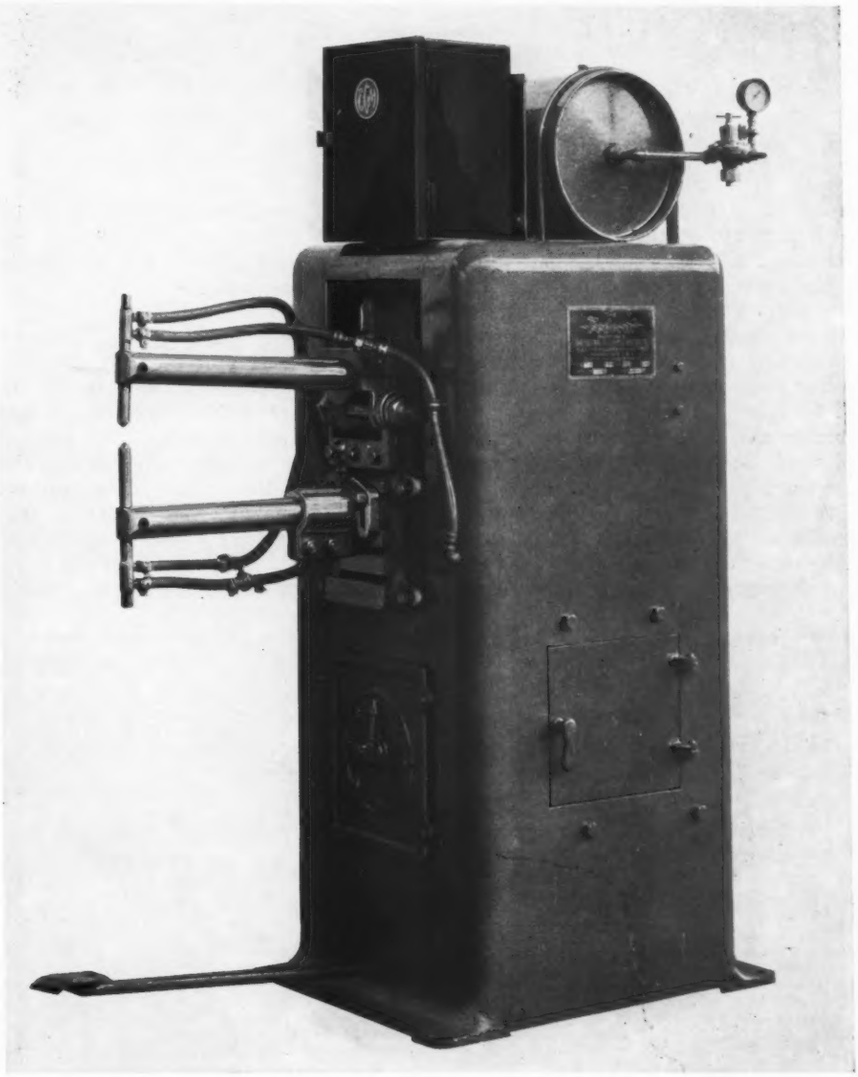


Fig 6—Easily adjustable welding is obtained by the use of air cylinders to move the electrodes

Fig. 7—Special machines such as this portable "gun welder" with air-operated electrodes are used for jobs too big to handle conveniently

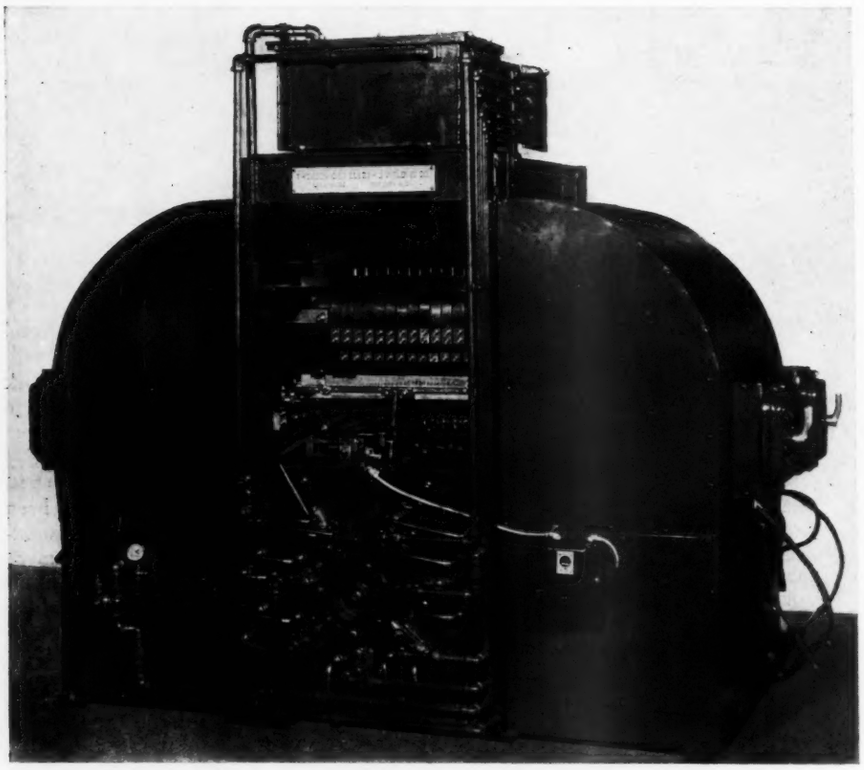


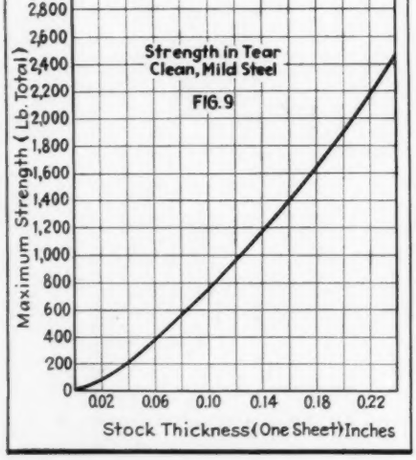
Fig. 8—Hydraulic valves and a pilot controlling the welding current are interlocked and successive welds are made without moving the work

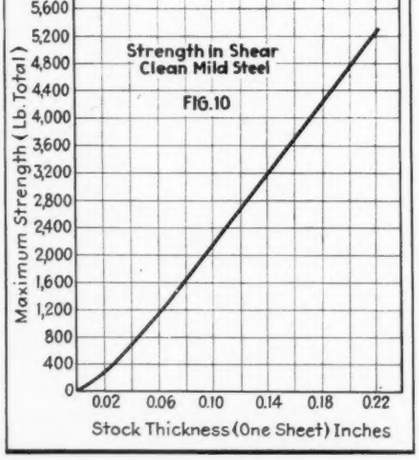
is shown in Fig. 8. In this design oil at high pressure is used to operate cylinders of small diameter. Oil flows to the cylinders successively, as determined by the rotary valve. A pilot switch operated by the rotation of this valve alternately energizes and de-energizes the main contactor simultaneously with the operation of the cylinders. Thus one or two transformers may be used to make a number of welds in succession without moving the work.

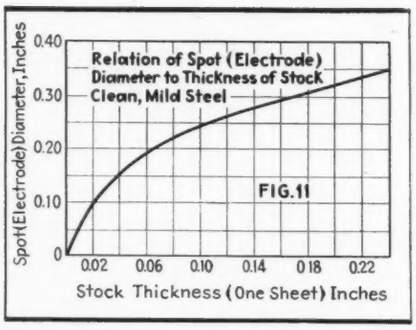
All of the machines described operate on the same general principles and are subject to the same requirements of control of current, time and pressure. Therefore in general the same factors which influence the design of work for spot welding apply whether the machine be manual or automatic.

Size and Spacing of Welds

In considering a problem in the design of parts to be resistance welded the logical starting point is the kind of material, its thickness and the desired strength of the weld. Assuming the metal to be mild steel having a maximum tensile strength of 60,000 lb. per sq.in. The strength of a spot weld may be measured by the pull required to tear a





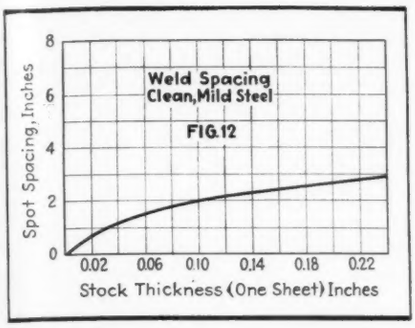


"button" or "plug" from the parent metal. Fig. 9 gives the strength of spot welds for various thicknesses of mild steel sheets. If the weld is subjected to shear only the data in Fig. 10 gives the strength of the weld. These values are the maximum as determined by tests. A factor of safety should be used either in determining the strength available or in the strength required. It is evident the values given in Fig. 9 and 10 must be based on a definite size of weld or spot. Fig. 11 gives the ratio of spot diameter to stock thickness. From the above the size and strength of the spot can be determined.

The next step is to determine the spacing of the welds. The spacing of the welds is not only a matter of strength but also of power requirements. If the spots are placed in close proximity more power will be required for the succeeding spots than for the first spot because there will be parallel current path after the first spot weld has been made. Fig. 12 gives data on the spacing of spot welds for different sheet thickness. The welds may be made as shown in Fig. 13a or as shown in Fig. 13b. If placed as shown in Fig. 13b. the strength can be calculated as per Fig. 10 instead of Fig. 9, because the forces subject the spot weld to shear only. If the forces acting on the sheets are as shown in Fig. 13c, the strength must be considered as shown in Fig. 9 and Fig. 13a, shows the best arrangement.

Welder Capacity Required

The above data is based on welding clean mild steel and since it is necessary to give data to cover average conditions it is possible in some cases to vary the values given, but the above data will permit determining the size, spacing and strength based on general practice. The next step is to find the capacity of the welding machine required. As shown previously the amount of current required depends upon the material to be welded, the material used in the electrodes and the pressure with which the surfaces are held together. Fig. 14 gives the electrical input required and Fig. 15 the pressure required for spot welding clean, mild steel.



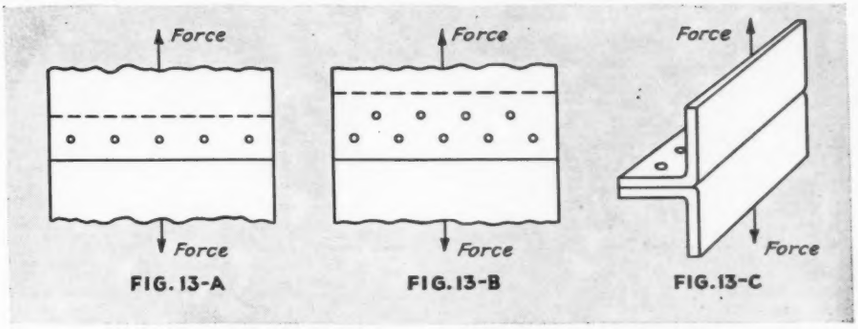
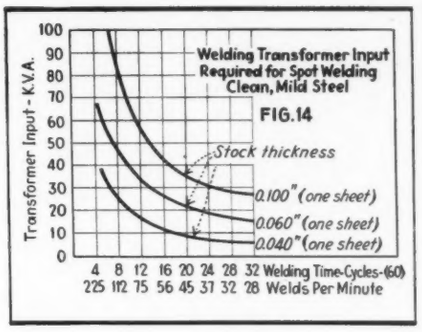
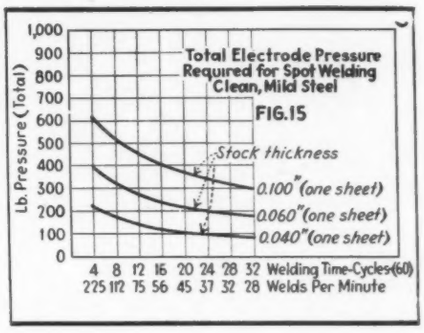


Fig. 13—Three types of spot welded joints, strengths of which are calculated as explained in the text

Required input to the welding machine is given in kva because this term is in common use. The best method, however, is to use the actual value of amperes required through the work. It is difficult to measure the current in the secondary or welding circuit of the machine and while transformer input does not necessarily give the secondary amperes or current flowing in the welding circuit. machines as produced by reputable manufacturers may be expected to produce results consistent with the data given in Fig. 14. The actual kva input to the welding machine is not necessarily the nameplate rating of the machine. Most welding machines are designed so that when operating under normal conditions of electrode arm spacing and electrode arm length the actual kva input will be approximately twice the rated value. In determining machine capacity for some of the alloys and less commonly used materials it will be necessary to consider the actual welding amperes required. The above data applies only to clean, mild steel.


Welding Transformer Input
Required for Spot Welding
Clean, Mild Steel
FIG. 14
Transformer Input - K.V.A.
Stock thickness
0.100" (one sheet)
0.060" (one sheet)
0.040" (one sheet)
4 8 12 16 20 24 28 32 Welding Time-Cycles-(60)
225 112 75 56 45 37 32 28 Welds Per Minute

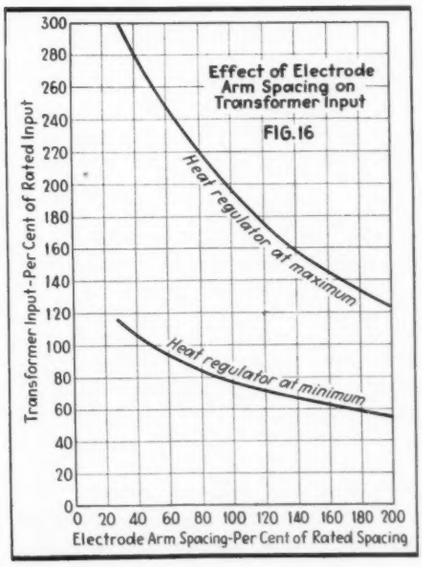

Total Electrode Pressure
Required for Spot Welding
Clean, Mild Steel
FIG. 15
Lb. Pressure (Total)
Stock thickness
0.100" (one sheet)
0.060" (one sheet)
0.040" (one sheet)
4 8 12 16 20 24 28 32 Welding Time-Cycles-(60)
225 112 75 56 45 37 32 28 Welds Per Minute

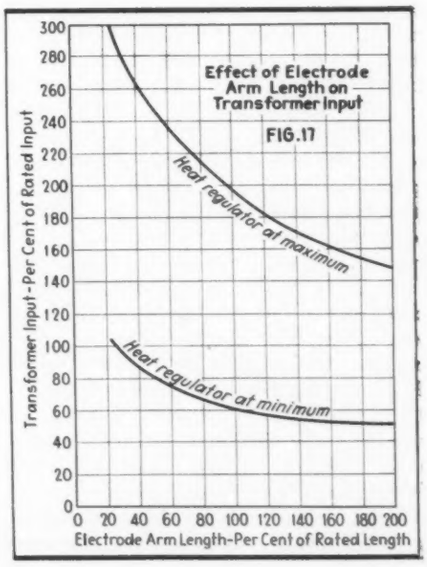
Factors Affecting Welding Time

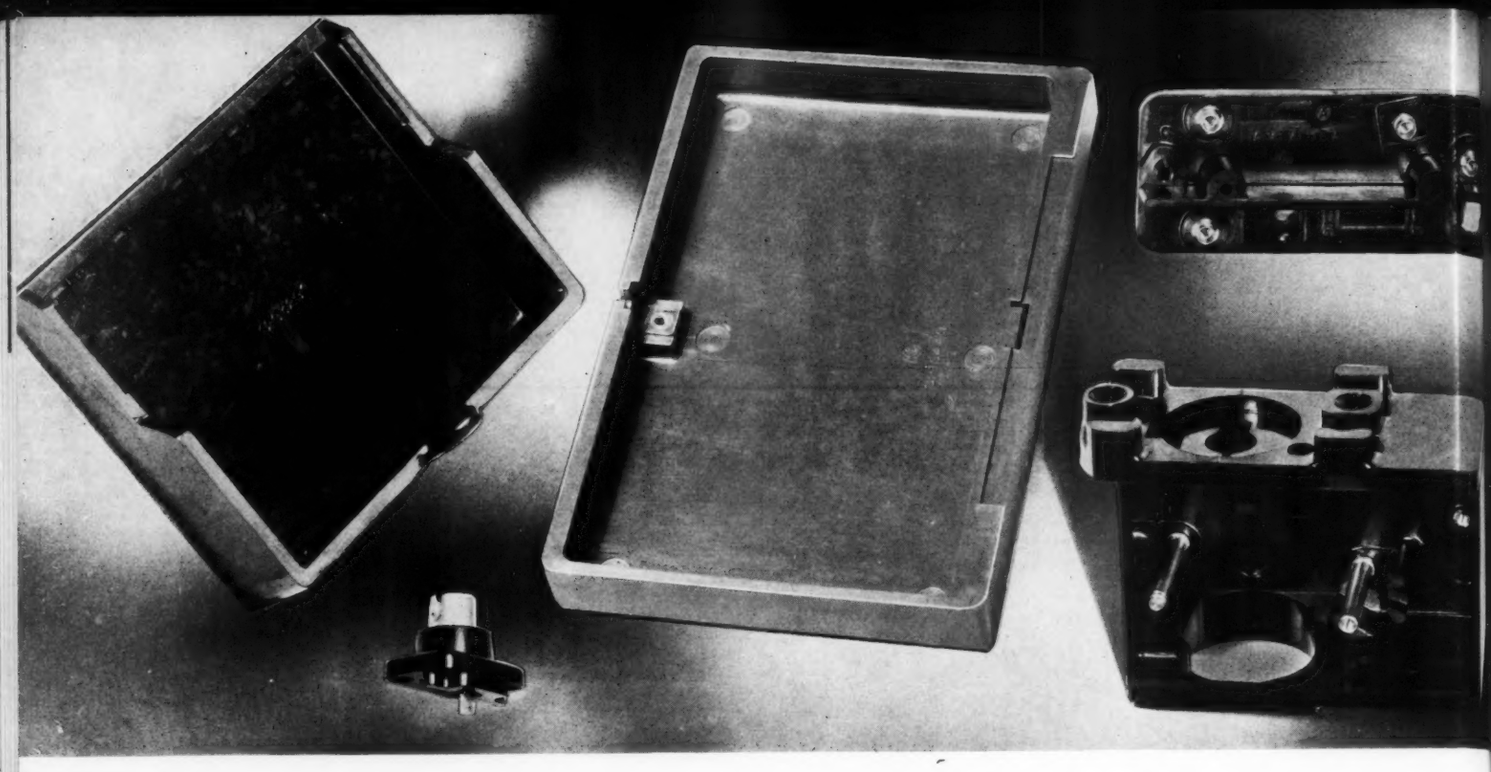
Resistance welding machines are usually designed for a wide range of work and have sufficient adjustments in their physical arrangement to accommodate various shapes and sizes of work. Thus the work may be held outside the throat or inside the throat. To provide for this variation the length of the electrode arms and also the space between them is usually made adjustable as is the spacing between the arms. Adjustments in the physical dimensions of a resistance welding machine are reflected in a change in the electrical output of the machine and, correspondingly, a change in the electrical input to the machine. Figs. 16 and 17 give the data for an average machine.

Before the machine capacity can be determined it is necessary to determine the time which may be allowed for the welding process. The curves of Fig. 14 and 15 show input against welding time. It will be observed that the input increases rapidly as the welding time decreases. This increase is largely due to the increased pressure required to obtain the proper forging operation in the shorter time interval. As a guide to selecting the welding time, these curves also show the number of welds per minute for average work. This is based on the welding time being one-fourth of the total welding cycle. It is obvious that other factors influence the number of welds per minute since when welding with short welding times it may require as long to move the work as when welding with longer welding time. The nature of the work must necessarily determine this. Using the most common form of electrode shape which is as shown in Fig. 1 (January *P.E.*), it is possible to prepare the work for welding from the above data provided no unusual conditions must be met.

As previously mentioned, one of the factors which influence the welding process is the electrode. The proper selection of electrode is as important as the cutting tools of a screw machine. While data is available concerning the physical and electrical properties of electrode materials the many varied shapes which may be used to accommodate the contour of the work are such that it will be well to thoroughly understand the factors which influence the choice of the electrode. Sufficient knowledge of the subject will permit the elimination of much of trial and error methods.


Effect of Electrode
Arm Spacing on
Transformer Input
FIG. 16
Transformer Input - Per Cent of Rated Input
Heat regulator at maximum
Heat regulator at minimum
Electrode Arm Spacing-Per Cent of Rated Spacing


Effect of Electrode
Arm Length on
Transformer Input
FIG. 17
Transformer Input - Per Cent of Rated Input
Heat regulator at maximum
Heat regulator at minimum
Electrode Arm Length-Per Cent of Rated Length



DESIGNING PLASTIC PARTS

Features That Reduce Costs and Increase Quality

FRANK H. JOHNSON

How production-slowing and spoilage-producing defects such as blisters, chipped corners, two-tone color effects and wavy surfaces can be avoided by correct design

MANY well-designed plastic pieces on the market today are ample proof that designers understand most of the problems involved in the molding process. On the other hand, designs impractical or impossible to mold are quite often given to the custom molder of plastics. It should not be inferred that serious difficulties are present in every molding job, yet too many pieces after having been put in production were finally turned out successfully only after serious molding difficulties were overcome.

Recent improvements in materials and molding equipment together with increased experience and greatly improved molding technique have brought about higher production efficiency for the entire industry, with the result that plastic products ave improved greatly in appearance, and average costs per unit have generally been lowered.

Great advances have been made in molding pieces of large overall size. A few years ago a plain ten inch supper plate represented the limit. Today the industry has presses available which produce large intricate radio cabinets, machine and instrument housings, and lighting fixtures. Furthermore the accumulated knowledge of specific characteristics of the various plastic compounds makes it possible for designers to select the proper compound with resulting reduction of spoilage and failures in the molding process.

The number of manufacturers who are incorporating plastic pieces in their products is increasing steadily. This means that design engineers are called upon more frequently to create products or units that are to be molded of plastics. To do this with the assurance that the utmost in efficiency, speed and low-cost production will be achieved it is necessary to know something about the details of the molding process. The effects of design details upon the article that will actually come out of the presses must be fully understood. Such production-slowing and spoilage-producing defects such as blisters, chipped corners, two-tone color effects and wavy surfaces can usually be foreseen and avoided through correct design engineering.

Granted that the eventual mechanical assembly of molded parts, economy of materials and the cost of dies are important factors in design, nevertheless they should not be adhered to if their value is overbalanced by slowed production or a prohibitive percentage of rejections.

There are four major features of design that should be avoided as far as possible because they have a definitely adverse effect upon the ultimate speed, efficiency and cost of production. These are:

1. Numerous or abrupt changes in the thickness of wall sections
2. Square corners
3. Undercuts
4. Large areas of smooth surfaces.

In practice it is recognized that demands of utility and design will make complete avoidance of these design features impossible. However, it is well to keep in mind that the final production cost of any molded unit will be lowered and the life of the article will be in-

creased if these adverse factors are reduced to the lowest possible point.

Wall Thicknesses

In general it is of great advantage to the molder if the thickness of wall section of the piece does not vary widely. He will always have to take sufficient time in the pressing operation to insure that the slowest curing portions of the piece, which are the thickest sections, are properly cured. It sometimes happens that, although the appearance of the piece to the casual observer may be good, if the heavy section were cut through, the center of the section would prove to be much undercured, which if not corrected would result in a shorter life for the piece because of cracking. High rejection percentages can be caused by the raising of a blister at these undercured areas after the piece has been removed from the die and examined by the operator. He may run a number of pieces before inspectors discover the fault.

In molding light colors from a urea material, a reduction of temperature with a correspondingly longer time in the press is necessary to prevent overcuring a thin section while a thick section receives a minimum cure.

The appearance of molded pieces can also be impaired by variations in thickness. As the press is closed the flow of material into the thick sections is fastest. This is followed by a forced flow into the thin portions as the material receives full pressure. This variation in flow is the cause of a great deal of the streaked or rippled effect on portions which are adjacent to ribbing and around the overflow. Warping, too, can be caused by the uneven cooling of thick and thin sections.

Corners

Rounded corners and generous fillets can be an economy of material as well as a method of cutting down the number of rejections. A square corner can be easily chipped in handling large quantity production. Internal stresses are lessened by rounding corners and gas pockets are often eliminated.

Appearance of the surface is improved by inducing a uniform flow of material while in the plastic state, with a consequent cutting down of finishing time because little buffing is required.

Undercuts

Undercuts necessitate, if the piece is not to crack, some elasticity in the material when the die is opened. Errors in judgment of a press operator will result in rejects, and far greater attention will be required to produce the piece than if undercut had not been incorporated. Therefore, wherever possible undercuts should be avoided.

Some manufacturers have been stripping undercut pieces with good results for years. Threaded closures have been run in this way with considerable success, chiefly in phenolic compounds. The thermo-plastic compounds, too, lend themselves to this operation as they are quite elastic if not too thoroughly chilled before removal from the die. The success with stripping urea materials has been less marked.

Smooth Surfaces

Another hazard to speedy and low-cost production is a large smooth flat surface. Common molding flaws in such an area are two-toned color effects, dirt, and wavy surfaces. If the material is black, the hazard is less than when this surface is a background for every speck of dirt that may settle on the die in the molding operation. Designs that provide for stippling where ejection will permit, and for fluting where possible, are an assurance of better appearance. If a large smooth surface is necessary, the handling of it will rest with the molder and material manufacturer and rejects usually can be held to a minimum by care in the operation of the press and by using the correct grade of material.

It is also recommended that ribbing be avoided as much as possible on the underside of a flat surface because the variations in thickness will produce rippling of the smooth top surface caused by a distorted flow of material and uneven shrinkage during curing and cooling. Streaking of the color on a flat surface can be caused by rubbing on the opposite side.

It is well to remember that greater success with flat surfaces is obtainable where they occur in a horizontal parting rather than in the vertical draw sections of the die. Uniform thickness at the cut off is advisable instead of extending ribbing for the full length of the draw.

Design Hints

Experienced designers of plastic units not only remember to avoid design features that invite trouble but they employ every known design trick to speed the molding operation and reduce rejects.

For instance the amount of taper on vertical draw dies is important; too much will do no damage, too little will result in bent and twisted pieces because of difficulty in removing the piece from the mold. Before deciding on the amount of taper it should be determined whether it is desirable for the molded piece to stay with the top or bottom half of the die. Too many dies have been built with knockout pins in the bottom half which when put in production are found to be useless because the molded pieces insist on staying with the top half when the die is opened. In general there should be less taper on the half of the die in which the piece is intended to stick.

The subject of metal inserts has long been debated, but the use of them seems to be increasing. The alternative is to provide a plain hole to be tapped in the finishing operation or into which a self-tapping screw is to be driven. The disadvantages of inserts are the cost of the insert, the danger of an insert floating off its pin and getting out of alignment, the weakening of the piece around the insert because of differences in coefficients of expansion of the piece and the insert, and also the added cost of placing the inserts in the die, which slows the molding cycle.

Placing of an insert, particularly heavy ones, over a thick section will sometimes so reduce the heat transfer from the die to the material behind the insert that blisters will occur at this point. For this reason it is well to keep material behind an insert to a minimum.

Tapping of the hole involves an additional finishing operation with fewer molding rejections and, if care is taken in the tapping, this is usually the safest method. Holes from which screws are to be removed often would be better with an insert but for ordinary assembly operations inserts can often be dispensed with since there is not much wear on the threads of the piece. Threads can be molded in the piece but the unscrewing of pins requires valuable time and causes considerable slowing-up of the molding cycle with resulting increase in unit costs. Self-tapping screws and force fits will be satisfactory if the piece is heavy enough around the hole. But if the hole is not backed up with sufficient material the piece is likely to break either at the time of insertion or later because of continued stress at that point.

Increased desire for color is largely responsible for advances in plastics, particularly where consumer goods are involved. There the increase in sales appeal has been definitely proved by those who have tried it. There are other considerations, however, the reduction of weight being one of the most important.

It should be remembered that when the savings in production and shipping costs made possible by reduced weight are applied to the cost of the dies it can be shown that expensive dies will soon pay for themselves.

Designers of new plastic pieces would do well to consult with molders and material manufacturers on new designs whenever that is possible. This service costs nothing and will often avoid expensive alterations in a finished die and upsetting of production schedules.

ADDING LIFE TO PARTS

With Hard Facings That Resist Wear

MILES C. SMITH

Factors for designers to consider when specifying the application of corrosion and wear-resistant overlays and alloy metals on machinery parts

NO LONGER considered exclusively a maintenance process, the welding of a layer of wear or corrosion-resistant metal to a parent metal is now being utilized by designers and fabricators of new machinery and equipment to lengthen the useful life of their products. Heat-treating, the welding on of overlays, and the casting of a few alloys into simple shapes comprised the processes which were employed a decade ago to secure desired wear and corrosion-resistant properties.

For obtaining such resistant-surfaces the designer now has additional processes to choose from; he can employ wear and corrosion-resistant castings that can be welded, brazed, or mechanically held in an assembly; he can use protective overlays that can be spun or cast on; he can also attain surface protection by electrolytic plating, by cold dipping, or by sweating a boride crystalline mixture into the skin of the parent metal.

In most efforts to secure wear and corrosion-resisting surfaces the chief objective seems to have been the attainment of extreme hardness, irrespective of the presence of or lack of other desirable physical properties. Although it has been proved incorrect many times, the theory that the wear-resistant property of metals is directly proportional to their hardness seems to be too generally held to be easily put aside.

Earlier Alloys Hard to Use

For the most part, the earlier metallic alloys of carbon, chromium, manganese, silicon and tungsten had a very complex composition. They were also difficult to make and difficult to use. Often these alloys checked and spalled to such an extent in service that many designers became discouraged and reverted back to the use of the common parent metals.

From the designer's point of view the important factors to be taken into consideration, when specifying wear-resistant and corrosive-resistant alloys or overlays, are the performance range of the overlay metals which are available, and the manufacturing advantages inherent in the several application procedures in the use of the various metals.

Avoiding Thermal Stresses

The designer and the fabricator of machinery and equipment need not have a thorough metallurgical knowledge of hard-facing alloys or of parent metals to apply these materials correctly. However, a sufficient acquaintance should be possessed with the physical characteristics and properties of metallic alloys as a whole to know whether or not two alloy metals can be expected to interalloy or to form a bond with each other when one of them is fluid. The designer should also know whether or not the fluid metal used can be depended upon to solidify without setting up stresses and strains that will destroy the structure of the parent metal.

The chief argument in favor of welded-on overlay or hard facing has been and still is that they can be placed at the point or over areas where the wear comes, the hard facing or overlays being applied by one of the welding processes.

Hard facing or welded-on overlays are castings which are formed of superheated metals while exposed to the atmosphere and allowed to chill very rapidly. When hard facings are bonded with a parent metal having a different coefficient of thermal expansion, strains or stresses are set up in the parent metal or in the facing as cooling takes place, possibly causing checks or cracks in the hard facing. Naturally, preheating the parent metal before the application of the hard facing, or normalizing after the hard facing is in place, tends to relieve some of the stresses and strains and to produce a more satisfactory assembly. However, it is impossible to get away from the natural physical tendency of metals to expand and cool in accordance with their respective coefficients of thermal expansion so that if liquid metal is poured over

Courtesy of Cincinnati Milling Machine and Cincinnati Grinders, Inc.

Blades of centerless grinder rest fabricated of wear and corrosion-resistant alloy castings brazed to steel bodies

the surface of another metal that is only moderately warm, the liquid metal upon cooling will contract so much more than the parent metal that there can be but one answer.

The ordinary type of hard facing is formed by melting down a welding rod or electrode with either an oxy-acetylene flame or an electric arc. The characteristics of the resultant structure depends greatly upon the operator and the capacity of the hard facing rod or electrode to harden from a fluid to a solid on the base metal without the formation of checks, cracks or gas pockets. Welding operators with only mediocre skill can form deposits that will be solid throughout and that will remain solid in service.

Overlays can be readily welded onto pure carbon steels. But, if it is desired to weld an overlay to alloy steel or alloy cast iron caution will have to be exercised to obtain good results. Some of the newer ferrous alloys oxidize at high temperatures and form exterior coverings of oxide which do not interalloy with the overlay. Other alloys do not oxidize at ordinary temperatures but do boil and give off gases which could be trapped in the welded-on deposit with resultant porosity. Some alloy metals have a high coefficient of thermal expansion, and others have a low thermal coefficient so that the stresses set up by a well bonded hard facing when cooling from a liquid to a solid state would warp or fracture the hard facing.

Overlays By Other Methods

There is another type of failure which should be guarded against when parent alloy metals are employed. The hard facing metal may, if it be puddled in with the parent alloy metal to any extent, poison and rob the parent metal of desirable physical properties. If the welding be done with an oxy-acetylene flame, the puddling can be prevented. However, if the welding be done with an electric arc the heat will melt the parent metal to such a depth that puddling to some extent cannot be prevented.

One solution of the problem is to use carbon steel as the base or parent metal wherever a welded-on facing is to be employed as a reinforcement, and allow the hard facing to take the severe service, even though the area of the hard facing must be increased many times that which would be necessary with an alloy metal as a base.

Any machine piece which is subjected to wear or corrosion over a relatively small area of an exterior surface can be protected and the life greatly increased by applying either a welded on or a cast on deposit of alloy metal which will resist much better either wear or corrosion than could the parent metal of the part.

Lately a process has been devised and adopted as a substitute for welded on overlays which has proven successful for many applications. This process consists in casting the wear or corrosion resistant alloys into shapes which are later either welded or brazed to the parent metal. This procedure eliminates any possibility of dilution of either the overlay metal or the parent metal. A prominent manufacturer of grinding machinery employs this method in the fabrication of grinder rests or blades for centerless grinding machines.

Another process, designed to eliminate several of the unwanted features of the welded-on overlay, is that of internally or externally spinning on a layer of hard facing material. This procedure, which is patented, consists in partially filling with hard facing metal the tube which is to be coated, then heating both until the hard facing metal is fluid and then spinning the tube until both are cold. The force of the centrifugal spinning action tends to eliminate any porosity in the overlay and also helps to secure a good bond between the overlay and the parent metal. This process is suitable for lining tubes, bushings and other cylindrical shapes.

Cast-on Overlays

There is yet another procedure which consists of casting on in a mold an outer shell of hard facing material to a parent metal. External protective surface to sleeves, plungers and shafts are applied in this manner. The overlay formed by this procedure is very much like the welded-on casting but there is not so much danger of porosity in the overlay and the process is less expensive than welding.

Some companies are using a process that forms the skin of the parent metal into a hard facing by sweating in metallic boride crystals. Others are employing a similar hard facing obtained by fusing tungsten carbide into the skin of parent steel in a non-oxidizing hydrogen atmosphere. Unfortunately tungsten carbide oxidizes readily and unless it is applied in an absolutely non-oxidizing atmos-

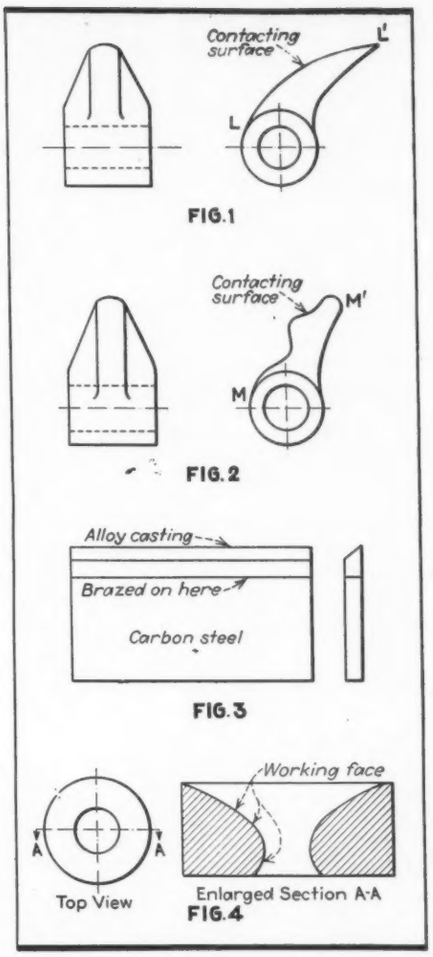


Fig. 1—Simple lever cam in which wear is on contacting surface L L' which is easy to cover by welding on process. Fig. 2.—Irregular shaped cam with a wearing surface which is difficult to cover by a welding-on process. Fig. 3.—Ideal application for the brazed-on casting, a typical grinder rest blade. Fig. 4.—When applying a shell of hard facing to the conical bearing surface of a die, to be successful the parent metal and the overlay metal must have unusual coefficients of thermal expansion to avoid strains and stresses that might cause checks

Table I—Physical Properties of Alloys Formed by Adding a Crystalline Metallic Boride Mixture to Cast Iron, Mild Steel and Tungsten Bearing Steel

Alloy	*Hardness Rockwell C*	*Tensile Strength lbs./sq. in.*	*Compressive Strength lbs./sq. in.*	*Coefficient Thermal Expansion*	*Density*	*Solidification Temperature F.* *Thickening*	*Solid*
No. 1, 87% cast iron, 13% crystals	62–63	Brittle	Brittle	0.000 009 34	7.55	2055	1990
No. 2, 19% tungsten, 62% steel and 19% crystals	63–65	47,047	235,890	0.000 005 06	8.26	2142	2135
No. 3, 75% pure nickel; 25% crystals	56–58	25,633	192,529	0.000 008 59	7.80	1990	1801
90% mild steel, 10% crystals as cast	63	50,219	490,960	.....	7.58	2375	2152
annealed	33	102,508	508,475	.....	....	....	....
hardened	62	107,068	440,437	.....	....	....	....

Table II—Some Properties of Alloys Obtained by Mixing Various Base Metals with Alloy No. 3 Metal Listed in Table I

Corrosion resistance: Copper losses are shown in milligrams per square inch of exposed surfaces; all other figures show per cent of weight loss

Description of Alloy	*Hardness Rockwell Scale*	*Sulphuric acid 1 to 4* Cold 100 hr.	*Sulphuric acid 1 to 4* 175 deg. F. 100 hr.	*Hydrochloric acid 1 to 1* Cold 100 hr.	*Hydrochloric acid 1 to 1* 175 deg. F. 1 hr.	*Nitric acid 1 to 2* Cold 100 hr.
No. 3 metal	58C	0.05	0.82	0.14	.....	4.22
Mild steel	....	57.69	31.72	27.00	20.45	10,000.00
Mild steel and 25% No. 3	6C	0.53	0.51	6.15	5.22	8.60
Cast Iron	50C	33.51	4.33	63.65	18.82	997.00
Cast Iron and 5% No. 3	56C	65.91	12.60	100.96	21.65	2,185.00
Cast Iron and 15% No. 3	29C	1.07	2.90	18.35	13.16	29.30
Cast Iron and 25% No. 3	28C	0.32	0.54	3.80	8.43	37.00
Copper	29B	2.20	....	28.30	....	.....
Copper and 10% No. 3	50B	1.69	....	40.70	....	.....

phere the yellow tungsten oxide will form and poison the parent metal as well as interfere with the formation of a satisfactory hard facing. The metallic boride crystals do not oxidize and may be applied in any sort of atmosphere.

One group of welding materials is made up of complex alloys which contain as essential elements iron, chromium, manganese, silicon and one or more alloying elements such as tungsten, boron or zirconium. Another group consists of simple alloys formed of various base metals with metallic boride crystals. A third group contains incidental iron, cobalt, tungsten, and chromium. Each group has its advantages and disadvantages from the welder's viewpoint, but only those materials in the last two groups can be considered very efficient for corrosive resistance.

Typical Applications

At present only a nickel boride alloy is available for casting on. This alloy is also suitable for the spinning process. A boron cast iron alloy is also available for the spinning procedure. Solid castings can be formed of practically any of the hard facing alloys, but only the members of the last two welding groups are in general use.

With a view to suggesting a procedure to the machine designer and fabricator, it might be well to analyze a few hard facing applications that are more or less typical. The wear on a simple lever cam, shown in Fig. 1, comes along the one contacting surface LL′ and the question arises what metal shall be used for the parent metal, what overlay or hard facing metal is to be used, and what is the most suitable application procedure.

Since the surface to be processed is easy of access, either the oxy-acetylene or the arc welding procedure should result in a solid, well-bonded overlay that could be ground to the desired smooth surface, general experience suggests that a welded-on overlay be used. Casting on, spinning on or brazing a casting on the cam shown in Fig. 1 would be troublesome.

It is not so simple to make a decision as to the procedure in overlaying an odd shaped cam like the one shown in Fig. 2. It would be more or less difficult to flow welding rod over the surface *MM′* to an even thickness. Here the brazed on casting or the cast on overlay would be much more economical. The cast shape of desired form and dimensions could be made in a baked sand mold or the cast on metal could be poured in between a parent metal base and a cast iron or copper mold, then after solidifying finished by a simple grinding operation.

The grinder blade or rest shown in Fig. 3 is an ideal application for the brazed-on casting. However, when the overlay must be thin the cast on procedure is the better one. Heavy overlays should be solid castings, thin overlays should be cast on.

Facings Inside of Cylinders

Cylindrical tube-shapes can be economically handled in two ways. If the hard faced lining is to be formed inside the cylinder spinning is the answer, but if it is the exterior which is to be entirely or partially covered either spinning or casting on is practical. The author prefers casting on for most exterior hard facing applications because less preparation is required and the process is easier to control. The cast on process is applicable to solid shafts of less than two inches in diameter and to hollow shafts of any diameter. The solid shaft of large diameter cools so slowly that a quick cooling overlay would be fractured by shrinkage stresses. The die shown in Fig. 4 is a good illustration of the necessity for considering the coefficients of thermal expansion and rates of cooling. Attempts to weld on an exterior overlay to cover the working face would probably result in the overlay cracking, or fracturing the die. The heavy section of the die cools so much slower than the shell of hard facing that the contracted overlay bursts or, if the bond between the parent metal and the overlay holds tight, the die is pulled in two. The only possibility of overcoming failures of this kind is to select a parent metal and an overlay metal with unusual coefficients of thermal expansion. Both must expand and contract very little through the wide range of temperature change from liquid to solid and vice-versa if bursting of the overlay or cracking of the die is to be avoided.

Courtesy of American Blower Corporation

Fan blade which was treated with sweat-in metallic boride crystals for wear and corrosion resistance in the flat blank and then formed to shape

WHAT IS NOT INVENTION

H. A. TOULMIN, JR.
Toulmin & Toulmin

This second article in the series has to do with attempts to make improvements upon previously patented inventions and describes some faults which may make such invention unpatentable

IN THE first article of this series, eight fundamental faults were discussed, any one of which prevents an "invention" from being patentable. They are: lack of novelty, lack of usefulness, failure to increase the usefulness of a previously patented device to a sufficient extent, harmfulness, simultaneous invention by several people, the exercise of mere mechanical skill, the exercise of mere engineering or designing knowledge and the mere improvement of the workmanship on a previous patent.

This article treats more specifically of the faults which are most likely to exist in the products of designers of machinery and equipment and to some extent of products intended for the ultimate consumer. The basic fault, which was discussed broadly in the first article, is that the "invention" fails to exhibit the exercise of imaginative, inventive genius, but is the result merely of the use of mechanical or engineering knowledge and skill which would be expected of anyone reasonably skilled in the every-day work of his trade.

Ingrafting New Ideas

Most of the faults listed, it will be noted, have to do with the attempt to make improvements upon previously patented inventions. This may at first glance seem discouraging, for in the present state of most arts it is rare for revolutionary inventions or discoveries to be made. Yet, in fact, there are in nearly all fields great opportunities to make improvements on existing patents which are themselves patentable. The courts have recognized this in a decision in which it was said:

"A new idea may be ingrafted upon an old invention, be distinct from the conception which preceded it, and be an improvement. In such case it is patentable. The prior patentee cannot use it without the consent of the improver, and the latter cannot use the original invention without the consent of the former."

In the same decision the court laid down the broad rules governing improvements in design as follows:

"But a mere carrying forward, or new or more extended application, of the original thought, a change only in form, proportions, or degree, the substitution of equivalents, doing substantially the same thing in the same way by substantially the same means with better results, is not such invention as will sustain a patent. These rules apply alike, whether what preceded was covered by a patent or rested only in public knowledge and use. In neither case can there be an invasion of such domain and an appropriation of anything found there. In one case everything belongs to the prior patentee, in the other, to the public at large."

There are several specific mistakes which the designer should carefully avoid if he hopes to patent the fruit of his labor.

1. CHANGE OF DEGREE. It is a common and perfectly proper activity of manufacturers to strive constantly to improve existing devices and products, but these improvements are patentable only if they are what might be called "revolutionary," and above all, if they display the exercise of true inventive genius. No matter how far other designers or inventors have carried on the work, if they have not succeeded in making the device workable they cannot patent it. But the one who sees the even slight change in degree which makes all of the previous work practical is, under the law, the inventor who is entitled to a patent.

However, most of the changes in degree which come out of design departments result merely from the application of common knowledge, technical ability and professional learning.

Thus a patent on paving blocks was invalidated on the grounds, as stated by the court, that, "What he did was to show that if the stones were used with rougher side surfaces than those found in the old pavements, all artificial means of keeping the transverse joints open might be abandoned. The change was only in degree and consequently not patentable."

The classic example of change of degree being unpatentable is that of the vacuum tube, or audion, which has been referred to in a previous article in *Product Engineering* but which is so striking an example that it is well worth emphasizing by repeating it here. De Forest held the patent on the device. Langmuir greatly improved its operation by increasing the degree of vacuum, but the Supreme Court held that this change of degree did not constitute patentable invention because the high vacuum was suggested by the prior art.

2. CHANGE OF FORM. This, it should be remembered, is not to be confused with questions of form as they apply in design patents to improve the appearance of a product.

To change the form of a product is not patentable invention except in the rare instances where it brings about an advance so marked that it results in an entirely new effect or a change that is revolutionary.

Thus, to make suspender ends of flat cord in practically the same way as they had formerly been made of round cord was held not patentable. In a somewhat similar case the court said:

"Although the patentee was the first to employ the combination claimed in the manufacture of round-cornered safes, the change from square-cornered safes was only a change in form." It was held not to be patentable invention.

Again the court held, "The particular sort of spring support and the wire mesh partitions partially covered with fabric . . . are but forms of construction within the range of ordinary mechanical skill. There was an utter absence of invention justifying the issue of this patent."

Adding New Properties

At another time the court cited a hypothetical case which makes the law quite clear. It said: "A distinction must be observed between a new article of commerce and a new article which, as such, is patentable. Any change in form from a previous condition may render the article new in commerce; as powdered sugar is a different article in commerce from loaf sugar, and ground coffee is a different article in commerce from coffee in the berry. But to render the article new in the sense of the patent law, it must be more or less efficacious, or possess new properties by a combination with other ingredients; not from a mere change of form produced by a mechanical division."

That rule can be applied in judging the patentability of any change in form which may occur to designers of any kind of product.

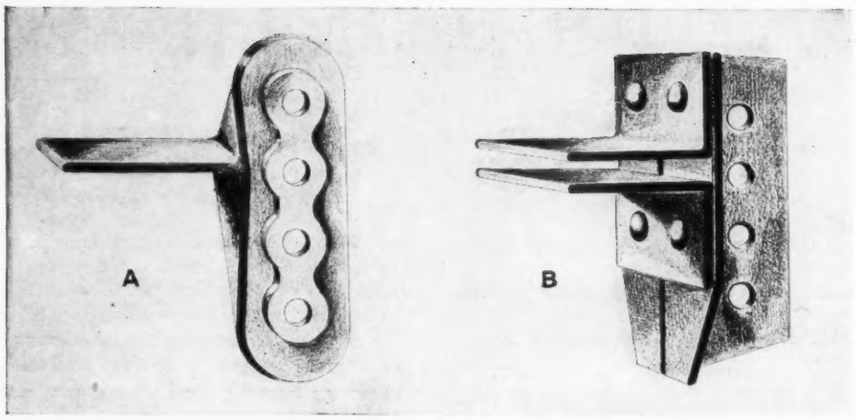


Fig. 1—Casting A replaced rolled angle assembly B. The appearance of A is better and cost is less, yet it involves no invention to make in one piece an article which has formerly been made by assembling two or more pieces

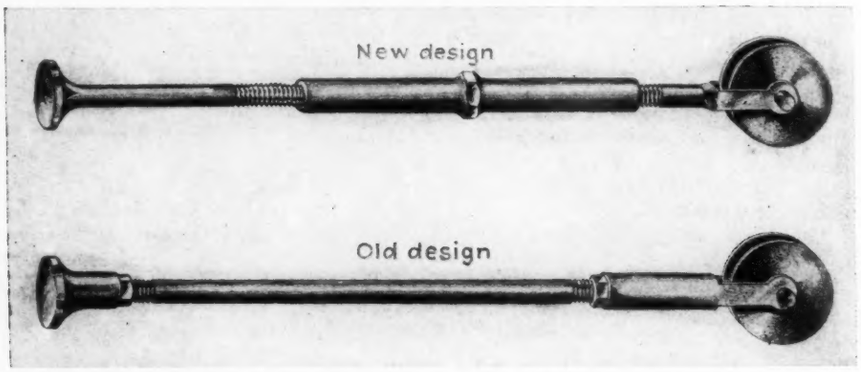


Fig. 2—Adjustable rods with sheave wheels and clevis both achieve the same result although parts are interchanged. The change in position of parts does not make the new device patentable

3. CHANGE OF PROPORTION. This is analogous in many respects to change in form. It is primarily a matter of mechanical or engineering skill. It is of importance to designers because it is usually a problem in mathematics based upon known engineering data and calls for the mere routine application of established principles of design. Thus, although the change in proportions of certain parts of an engine admittedly made the frame lighter and stronger than before, it was held not to be patentable.

4. ENLARGEMENT. While it may take a high degree of engineering talent to make a product—a bridge for example—larger than it has ever been made before, it is not patentable unless there has been a radical change in the organization of parts. In a case involving the increase of size of a saw-mill machine, the court said, ". . . the enlargement . . . of the machine . . . does not afford any ground . . . for a patent. This is done every day by the ordinary mechanic in making a working machine from the patent model."

Again: "True, a larger transformer and greater radiating space gave more power, but mere increase in the size of parts of a well-known device has never been held to be patentable."

The same rule has been applied when the increase in size brought new results. Thus, the court invalidated a patent on a hose reel of such large diameter as to allow water to pass through the hose while it was still partly wound upon the reel, thus permitting water to be played upon a fire sooner than it could be when the hose is wound on a small reel.

5. MAKING A STRUCTURE INTEGRAL OR SECTIONAL. Combining separate parts, or dividing one part into several, is not patentable. There are numerous decisions crystallizing this point. To quote two of them: ". . . the patent . . . is void . . . because it involves no invention to cast in one piece an article which has formerly been cast in two pieces and put together." Again: "Assuming . . . that the patent disclosed a single coupling rod made up of two pieces rigidly joined by his locking disks, it seems to us an obvious modification to manufacture the two pieces into one . . . From that idea it necessarily followed that the overlapping space could be eliminated, both in the interest of economy and of a somewhat nicer adaptability."

6. CHANGE IN POSITION OF PARTS. To change the position of parts of a device is not patentable unless the result is not only new and useful but unexpected as well. If done to adjust a machine to another, or to fit it into an odd shaped space, is not enough. It must achieve a desired result and not be a mere improvement in degree. Some court decisions:

"They are substantially the same wheel . . . and whether used as turbines, or only under the operation of a spout, they anticipate his structure. The mere change of use by placing them in a different position with regard to the water is not patentable."

A second: ". . . the invention of Ide consists only in removing the governor, with the dash-pot, from a separate wheel to the fly wheel. If the dash-pot performed any new function when attached to the governor in the fly-wheel, such change in location might be the basis of a patent; but the testimony is that it was attached to the Buckeye governors for the very purpose for which Mr. Ide attached it to his governor, and that it accomplished that purpose to the entire satisfaction of the parties interested."

Again: "The providing of spaces for the bonds, and the change in the order of arrangement of the coupons, cannot, upon the most liberal construction of the patent laws, be held to involve any invention."

7. REVERSAL OF PROCESS. To reverse the steps of a process or the arrangements of parts of a machine is not patentable unless it brings an unexpected result or an improvement in the quality of a result which is of great importance. Merely to change the degree is not patentable. That is expected of capable designers or mechanics.

One case had to do with the substitution of a movable tracker bar for a movable frame in a device where it was necessary for a part to come in contact with perforations in paper. It was held that when two objects are so situated that one must come in contact with another it makes no difference which one is moved.

In another case, the court said: "The only difference in any respect that I can discover between these two patents is that (in one) the spring is extended and works by contraction, while (the other) contemplates that it should work either by compression or extension. But, as a mechanical movement, it is immaterial whether it works one way or the other. The essential thing is the action of the spring when the dead-center line is crossed, and it matters not in which way this is obtained."

The next article in this series will discuss further points of importance to designers and inventors in regards to unpatentable features of products.

PROTECTIVE COATINGS

for Product Finishes

J. DELMONTE

An explanation of the inorganic protective coatings for rust resistance and for improving the quality of organic coatings that may be applied over them. Phosphating, chromating, oxalating, oxidizing and silicating are included.

INORGANIC protective coatings for various metals are produced by chemical immersion, by spraying and by electrolytic means. The base metal receives not only additional protection against corrosive influences, but it also is prepared in a manner conducive to the adherence and durability of further organic coatings that may be applied. The surface conversion treatments may be divided into five categories:

1. Phosphating
2. Chromating
3. Oxalating
4. Oxidizing
5. Silicating

For ferrous metals, phosphating and chromating are the most popular methods of coating. The phosphating processes are the oldest. New methods of applying phosphate coatings which have been developed since that time give protective coatings that are slightly different in physical structure and behavior. The chromate coatings, a comparatively recent development, likewise exhibit promising results and certain economies of application. Much discussion has ensued as to the comparative qualities of these protective coatings and conflicting reports have appeared. It has been suggested that variance in the base materials submitted for tests has been an important reason for differences in results, in that it has a decided bearing on the effectiveness of the finishing procedure.

Other considerations, such as the methods of application of the protective coating, should influence the manufacturer in selecting a desirable surface conversion treatment. Initial expenditures may be reduced considerably by examining existing tanks and equipment in the light of their possible change-over to new processes. As for the actual details of the processes, and the results achieved, attention is invited to subsequent paragraphs.

PHOSPHATING—The formation of an insoluble non-metallic phosphate coating upon metals has been a decided asset to the attainment of durable and lasting finishes. Automobile manufacturers are one group who frequently resort to phosphate coatings of sheet metal parts prior to applying the final finish. A protective phosphate coating beneath a paint finish protects the base metal when the organic coating is scratched or chipped. If the phosphate coating were not present the base metal would rust under corrosive influences and undermine the organic coating, spreading out from the position of the scratch.

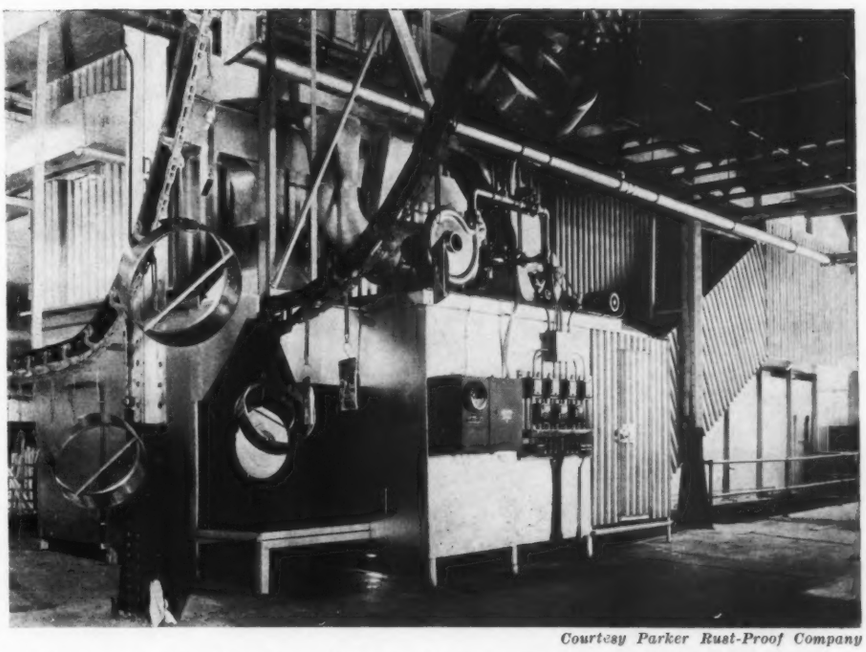
Phosphate coatings on iron, steel, or zinc are accomplished by treating the cleaned metal with acid phosphate solutions, containing a small amount of free phosphoric acid, at a temperature up to 210 deg. F. The iron on the surface is partially dissolved with the result that an insoluble phosphate coating forms. The reaction may be appreciably accelerated by the presence of small amounts of copper in the solution.

The phosphating may be accomplished by several methods:

(a) Immersion phosphating
(b) Spray application
(c) Dip spray application
(d) Electrolytic method

The oldest method of phosphating utilizes a dip process. After a thorough cleaning of the metal objects, they may be suspended from racks or placed in baskets, and immersed into the solution. Small articles are conveniently processed in tumbling barrels. The process requires anywhere from ½ to 2 hr., depending on previous cleaning of the surface, concentration of the solution reagents, and the type of metal being treated. This treatment, sometimes known as normal phosphating, utilizes phosphoric acid at a temperature of about 210 deg. F. Chemical loss through processing may be indicated by simple tests, and the solutions replenished as needed.

The heavy, crystalline phosphate coating that is obtained through this



Courtesy Parker Rust-Proof Company

"Easy" washing machine parts, hung on the conveyor entering the Bonderizing section

process offers suitable protection against corrosive influences. Dipping the article in stain, oil or paint after normal phosphating increases the corrosion resistance of the coating. In addition, sheet stock may be rinsed well after phosphating, and stored for long periods without rusting. It is a good practice to seal a final, porous phosphate coating with a thin layer of oil or transparent lacquer. Also, a coating obtained in normal phosphating may not be satisfactory on structures or surfaces subjected to bending because the brittle nature of the heavy crystalline phosphate layer might result in its cracking. Likewise, the comparatively coarse phosphate structure is not as desirable for a paint, enamel, or lacquer undercoat, as are the finer-grain coatings obtained by other processes.

There are other phosphate immersion processes which attain the protective properties of the phosphate layer in a much shorter period of time. In a solution of phosphates and activators, the coatings are developed by the chemical action on the metal itself. The phosphate coatings developed by these methods are relatively thin, possessing a porous minute crystalline structure, easily adapted to final organic finishes. This structure may be better visualized by closely examining the micro-photographs of an untreated piece of steel and a piece that has received a fine phosphate coating.

The fast phosphate dipping processes, as differentiated from the slow phosphate immersion, are completed in 2 to 5 min. These processes lend themselves to rapid mass production methods. The solutions are prepared with the ingredients in proportions that will permit the formation of the phosphate coating in a minimum of time. A typical solution contains free phosphoric acid, metal acid phosphates and accelerators. As before, the articles may be hung on racks or placed in baskets prior to the immersion. During this immersion the processes are carried out at a temperature of about 205 deg. F., or in the range of 150 deg. to 170 deg. F., depending on which particular process is used. It will be necessary to maintain a closer chemical control on these solutions, than otherwise required for the longer phosphating processes.

Spray Phosphating, which requires only about 1 min., produces a denser and more compact coating on the metal and uses more dilute solutions at lower temperatures. It is ideally suited for continuous production operations where the work is carried on a conveyor to the multiple series of power sprays. The chemical solutions are forced through numerous small nozzles in a series of standpipes. These solutions are maintained at a temperature of about 170 deg. F., and the actual time of operation is one minute or less. From the phosphate spray, parts are usually conveyed to the washing and rinsing chambers. These operations may easily be made automatic, particularly if the parts are of uniform size and shape and are passing along the conveyor system. The spray methods of phosphating are applicable to manufacturing establishments where mechanical conveyors are available.

Dip Spray Phosphating extends the advantages of the dense corrosion inhibiting phosphate coatings obtained in spray phosphating to manufacturing establishments that are not equipped with mechanical conveyor systems and manufacture products of greater varia-

TABLE III — COMPARISON OF

	Type of Coating	Methods of Application			Type of Metals Treated	Specific Advantages
		Process	Time	Temperature		
1.	Phosphate	Slow Immersion	1–2 hrs	210 F	Iron and steel	Rust preventive without addition of further organic coatings.
2.	Phosphate	Fast dip	2–5 mins	205 F	Iron, steel and zinc (including galvanized iron)	Rust protection and good adhesion for further organic coatings. (*Ditto for other phosphate coatings listed below.*)
3.	Phosphate	Spray	2–5 mins	170 F	Iron, steel, zinc and cadmium surfaces	A more dense and uniform phosphate coating than obtained in dipping.
4.	Phosphate	Dip spray	2–5 mins	180 F	Iron, steel, zinc and cadmium surfaces	More dense and uniform coating. Applicable to those parts unsuited for spraying.
5.	Phosphate	Electrolytic	3–5 mins	150 F	Iron and steel	Dense, fine grain zinc phosphate coating.
6.	Chromate	Slow Immersion	1–2 hrs	210 F	Magnesium, iron, steel or aluminum	Passivates surface by inhibiting rust.
7.	Chromate	Fast Dip (1)	½–2 mins	180 F	Iron and steel	Rust inhibitor — Very thin film formed.
8.	Chromate	Fast Dip (2)	1–2 mins	Room temp.	Magnesium alloys	Rust inhibitor — Good under coat for organic coatings.
9.	Chromate	Fast Dip (3)			Zinc alloys	Rust inhibiting.
10.	Oxalate	Dip			Iron and steel	Rust protection and adhesion for further coatings.
11.	Oxide	Electrolytic			Aluminum	Corrosion resistance, and excellent base for further finishes
12.	Oxide	Dip	5 mins	140 F	Iron and steel	Scratch proof base for further finishes, appearance.
13.	Silicate				Iron and steel	Flexible — Good for elec. steels

tion in size and shape. As with the spray-method, a wider range of metals also may be treated, including in addition to iron and steel, zinc alloys and cadmium surfaces. The immersion tank is equipped with a bank of power sprays directly above the solution, and the work must pass through the sprays before reaching the solution. A pump continuously circulates the chemical solution from the main tank to the spray nozzles which empty their contents in the aerating chamber above the main tank. The solution is maintained by steam coils at a temperature of about 180 deg. F., while the processing time is 2 to 5 min. depending upon the product and the type of metal treated.

ELECTROLYTIC PHOSPHATING produces a smooth corrosion-inhibiting coating on steel. The articles are immersed in a tank and alternating current is applied for about 4 min. A very dense coating of zinc phosphate is obtained. Instead of depositing zinc as in direct current electrolysis, the metal is coated with a continuous surface of zinc phosphate. By dividing the articles into one, three or five separate groups, each acting as an electrode, it is possible to avoid wastage of the coating material on the sides of the tank, which otherwise would serve as an electrode. A bath temperature of about 150 deg. F. is usually maintained. Checks on the bath chemical concentration are required, to maintain proper operating solutions. This method, like the dip method, lends itself to the coating of miscellaneous steel parts. It has an advantage over the straight dip process in that a more uniform and denser protective phosphate coating is obtained, particularly on flat surfaces. But the parts must make good electrical contact and for irregular shapes and deep recesses the throwing power of the solution must be sufficient to give uniform results.

Advantages and disadvantages of the various chemical phosphating treatments are outlined in Table III.

CHROMATING—Within the past several years the chromating process for steel and iron has been developed. The chromating process, like the phosphate treatment, tends to improve the adherence and durability of subsequent organic coatings. Whereas the phosphate coating acts in the capacity of a protective layer for iron and steel, separating the base metal from the outside, the chromate process passivates the electro chemical forces that cause rust formation. Special chromate treatments are not confined to iron and steels, for there are processes that are highly desirable for zinc and magnesium alloys. Organic finishes, as on magnesium alloys, are more lasting when preceded by a chromate treatment.

Chromate layers are quite thin, being considerably thinner than the phosphate layer. It is claimed that in bending a sample of metal treated by the chromate process, the chemical chromate film is not cracked, which may occur in the phosphate layer. The chromate treatment is generally applied by immersion treatments, though it can be applied by spraying. As with the phosphates, there is a slow and fast process, the latter more adaptable to meet the requirements of mass production.

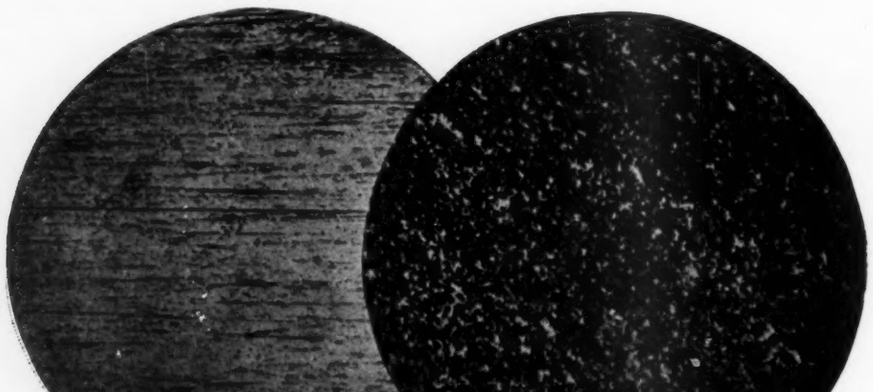
FAST CHROMATE IMMERSION—The action of chromic acid on iron and steel, when used under proper conditions in the presence of activating agents, will passivate the mechanism of rust formation on the surface. Chromic acid alone has little or no effect, therefore

CHEMICAL SURFACE TREATMENTS

	Type of Coating	Applicable To	Unsuited For	Typical Tradenames
1.	Phosphate, Immersion	Miscellaneous products — screw machine parts, stampings, forgings, etc	Mass production of medium and large parts.	"Parkerizing." "Granodine."
2.	Phosphate, Dip	Miscellaneous small and medium size parts, forgings, castings, cold rolled steel.	Parts subject to further fabrication, as drawing, forming, etc.— very large assemblies.	"Bonderizing" (also "Paintagrip" on galvanized sheets.) "Granodine" for steel. "Lithoform" for zinc.
3.	Phosphate Spray	Large and medium size parts moving on semi-automatic conveyor.	Small machine screw parts, stampings, etc.	"Spra-Bonderizing." "Spray-Granodizing."
4.	Phosphate, Dip Spray	Medium and miscellaneous parts suspended from racks.	Very large parts and closely packed small parts.	"Dip-Spra-Bonderizing."
5.	Phosphate Electrolytic	Miscellaneous and medium parts where low voltage alternating current is advisable.	Very large parts	"Electro-Granodizing."
6.	Chromate Immersion	Miscellaneous products — screw machine parts, castings, extruded parts, etc.	Mass production of medium and large parts.	.....
7.	Chromate, Fast Dip	Miscellaneous small and medium size parts — cold rolled steel.	Large assemblies — and where appearance is a factor.	"Cromodizing."
8.	Chromate, Fast Dip	Castings, channels	Large assemblies	.....
9.	Chromate, Fast Dip	Die castings, small zinc parts	Large zinc or galvanized surfaces	"Cronak."
10.	Oxalate	Miscellaneous small and medium size parts.	Large assemblies and where further fabrication is necessary.	.....
11.	Oxide	Sheet, bar, rod stock and castings	Large assemblies, certain parts of elec. equipment.	.....
12.	Oxide	Tools, miscellaneous small articles	Large assemblies	"Jetal."
13.	Silicate	Sheet steel	Miscellaneous articles	.....

chemical salts are added to the bath. The total time of treatment is ½ to 2 min. at a temperature of about 180 deg. F. As with any of the immersion processes, the labor of handling the individual parts may be minimized by semi-automatic conveyors that carry the parts from one tank to another. Special chromic acid solutions are often prepared for magnesium alloys. One recommended procedure for magnesium castings specifies a solution of 1 lb. of chromic acid and 1 lb. of nitric acid, to a gallon of water. The treatment requires about 2 min. at room temperature. In addition, there are special chromate solutions for treating zinc and zinc alloys that are subject to severe corrosive conditions.

SLOW CHROMATE IMMERSION — Though the demands of mass production methods are usually too rapid for the slow chromate immersions, they are still used, nevertheless, for close chemical control and highly accurate process conditions are not essential. The treatment usually consists of boiling in sodium or potassium dichromate for 2 hr. As with the fast chromate immersion, a tinge of yellow-brown appears on the metal surface being treated.



Untreated steel (100x) showing the lack of uniformity of surface and smooth areas where it is difficult for finish to adhere. To the right is a typical Bonderited surface (100x) showing the uniform crystalline coating which holds the paint or lacquer tenaciously

Though this coloration lacks ornamental appeal, it fulfills its purpose as a rust inhibitor. Aluminum alloys are sometimes treated by the chromate processes, the yellow discoloration being quite apparent in the presence of the comparatively white background of aluminum oxide.

OXALATING—The oxalate processes are not as widespread as the other chemical treatments. In effect, they are immersion processes, a ferrous oxalate coating being produced on steel surfaces. The oxalate process is designed to prevent the spreading of rust from scratches in the paint and also to promote the adhesion of paint or lacquer.

OXIDIZING—Surface oxidizing processes are particularly valuable in the preparation of durable finishes for aluminum and aluminum alloys. Aluminum is an unusual element in its resistance to corrosive influences. Because of its relatively high electro potential one would expect considerable surface activity. However, the opposite is true and a thin, hard, non-porous oxide layer voids the propensities of aluminum toward atmospheric corrosion. The thickness of this protective oxide coating may be increased superficially by an anodic oxidation process. Several methods are in existence for electrolytically treating aluminum surfaces. The aluminum or aluminum alloy part is made the anode in a mild caustic bath, and sides of the tank serve as the cathode. An oxide layer, 0.0003 in. to 0.0004 in. thick is deposited. Aluminum oxide has good electrical resistance, a fact to remember when applying an anodic treatment to aluminum parts intended for electrical apparatus, inasmuch as it must be removed prior to establishing electrical connections.

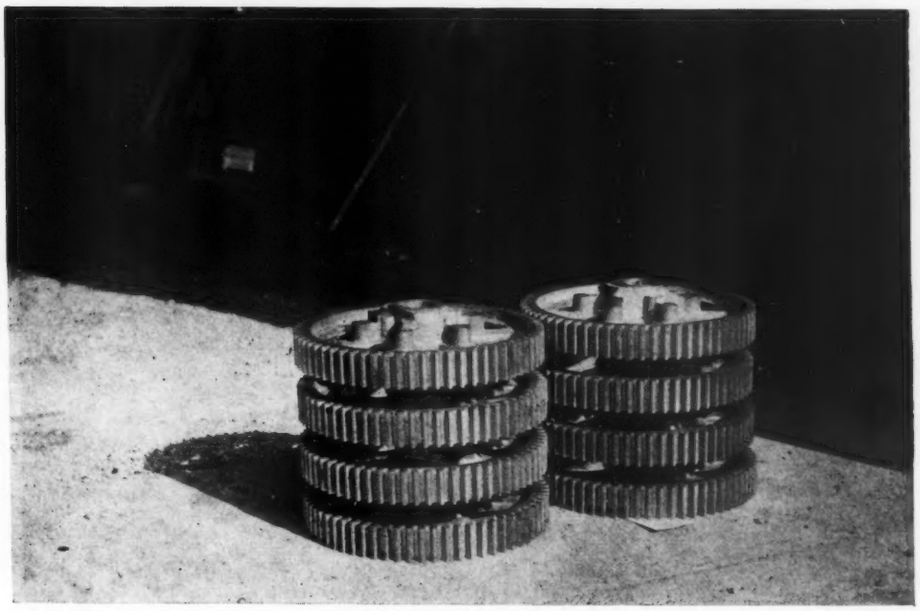
SILICATING—Of specialized interest to sheet electrical steels are the sodium silicate coatings that are sometimes employed. These coatings are crystalline in nature, appearing under the microscope similar to a fine phosphate coating. They are very flexible and will not crack when the sheet is bent. The fact that the silicate coating is a non-conductor of electricity permits it to be used on laminations for small motors and transformers.

Though the preceding paragraphs and tables but briefly review the chemical treatments and surface characteristics, much can be said about the comparative advantages. The phosphate treatment and the chromate treatment are the subjects of the comparative discussions. On one hand, the phosphate coating will provide complete rust protection, depending for its efficacy upon the fullness and the denseness of the phosphate layer. These coatings sometimes serve as final finishes, a dark oil stain being usually added to improve the appearance of the usual dull gray finish. Besides, the interstices of the crystalline finish provide an excellent base for further organic finishes, promoting greater adhesion and thereby greater durability.

However, this same protective layer is not wholly desirable on metal parts that are to be subjected to further bending of sufficient magnitude to crack the phosphate layer. This objection is overlooked sometimes in the light of the rust protection offered to galvanized sheet steel stock, which may be subjected to further fabrication. Sheet stock that is coated with a phosphate layer may be expected to be reasonably free of rust when stored for long periods of time.

On the other hand, the chromate treatment inhibits the rust on the surface of the metal. This action is desirable from the standpoint of further organic finishes, inasmuch as greater life is assured the final coating. Though it does not offer as full a protection as a thorough and dense phosphate coating, there are other advantages that tend to make chromate treatments a competitive material. It is reported that on a cost comparison basis, chromate treatments are less expensive. As a matter of fact, a few of the automobile manufacturers have applied chromate treatments to the sheet metal parts of their cars, prior to the final coatings. Another advantage claimed for the chromate treatment is that the much thinner chromate film will not crack as readily as the phosphate layer, when distorted. However, for best results, the chromate treatment must be applied directly before the final coating, inasmuch as it will not offer the rust protection that the phosphate coating offers, when exposed in an unfinished state to corrosive conditions.

Aside from other considerations, the manufacturers are concerned with the initial cost and maintenance of the equipment required for the chemical surface treatments. Where the average production run of a particular article is high, and requires a chemical surface treatment, the installation of the tanks and equipment would be the best plan. However, when random lots only are to be treated by either of these methods, the local jobber who is equipped to do the work, should be consulted.



IRON AS A GEAR MATERIAL

D. W. DIEFENDORF
Vice-President, Diefendorf Gear Corporation

Why the greater elasticity of the modern high-quality alloy, cast irons lower the stresses and increase the wear resistance of gears. This analysis applies to many other machine elements

BETTER foundry practice, better metallurgy and a better knowledge of the physical properties of alloy cast irons have regained for cast iron much of its lost popularity. This applies especially to the use of nickel alloyed gray iron castings for gears.

The application of nickel alloy iron to gearing problems may be divided into two phases: namely, using it to replace present gray iron gears which do not have the required strength and are continually failing through breakage; and using it in the design of new gear drives, taking into consideration the minimizing of tooth loads, increasing the wear values, and maintaining a low cost design.

Strength Considerations

With reference to replacing plain gray iron gears with alloy iron gears, it can readily be shown that by the use of the proper alloy iron the beam strength can be increased as much as 75 per cent. According to the familiar Lewis formula for calculating the strength of gear teeth, the beam strength of a given tooth is directly proportional to the safe static beam strength of the material. That is, the safe tooth loading is directly proportional to the tensile strength of the material, at least in the case of iron or steel.

Referring to the accompanying Table I of the physical properties of some irons and steel, semi steel is almost 50 per cent stronger in tension than is plain gray iron, a 1.25 per cent nickel iron is 60 per cent stronger and a 2 per cent nickel iron is about 75 per cent stronger. These figures do not take into consideration the much better resistance of nickel iron to impact load and shocks, or the inherent soundness of a nickel alloy iron casting as compared with the old fashioned plain gray iron.

But of greater significance are the properties of alloy gray iron in relation to gear design from the standpoint of minimizing tooth loads and increasing the wear resistance of the gears. Here the inherently low modulus of elasticity of gray iron, alloyed or unalloyed, is the vital factor.

Dynamic Tooth Loads

It can be shown that with gears running at moderate or high pitch line velocities the actual load on the teeth is many times that of the load transmitted by the gears. This load is caused by inaccuracies in tooth profile and spacing which

Table I—Physical Properties of Some Steels and Irons

Material	*Per cent Nickel*	*Per cent Steel*	*BHN*	*Tensile Strength*	S_t	S_c	*Modulus of Elasticity*
Gray Iron	...	.....	160	24,000	12,000	90,000	15,000,000
Semi-Steel	...	15–40	190	34,000	17,000	90,000	17,000,000
Nickel Iron	1.25	20–40	200	38,000	19,000	90,000	19,000,000
Nickel Iron	2.00	30–70	220	42,000	21,000	90,000	20,600,000
Steel	...	100	150	72,000	36,000	50,000	30,000,000

tend to accelerate and decelerate the moving masses.

Thus, when:

W = total applied or transmitted load, lb.

V = pitch line velocity, ft. min.

hp = horsepower transmitted.

W_d = total dynamic load.

C= deformation factor.

F = face width, in inches.

e = cumulative error in tooth profile and spacing of mating gears, in inches.

E_1 and E_2 = modulus of elasticity of materials.

ϕ = pressure angle of tooth.

Then:

$$W = \frac{33{,}000\ hp.}{V}$$

$$C = \frac{K\,e}{\frac{1}{E_1} + \frac{1}{E_2}}$$

$$W_d = \frac{0.05V\,(F\,C + W)}{0.05V + \sqrt{F\,C + W}} + W$$

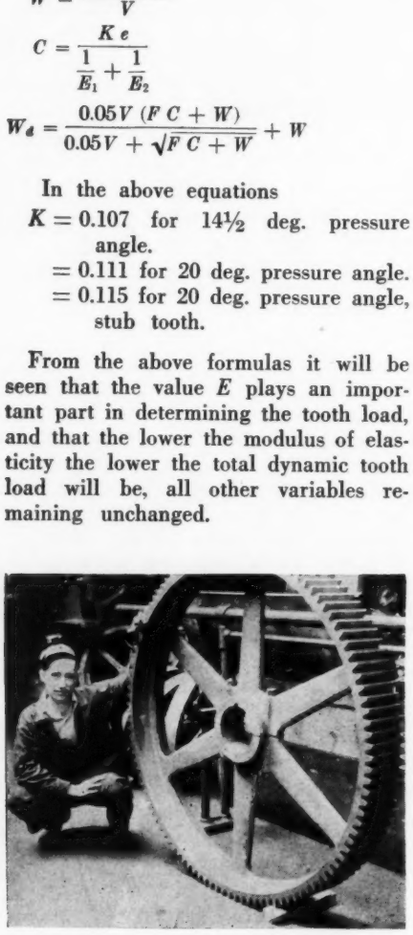
In the above equations

$K = 0.107$ for 14½ deg. pressure angle.

$= 0.111$ for 20 deg. pressure angle.

$= 0.115$ for 20 deg. pressure angle, stub tooth.

From the above formulas it will be seen that the value E plays an important part in determining the tooth load, and that the lower the modulus of elasticity the lower the total dynamic tooth load will be, all other variables remaining unchanged.



This same property, low modulus of elasticity, also plays an important part in increasing wear factors for a set of gears:

When:

W_w = limiting tooth wear load, lb.

D = pitch diameter of pinion, in inches.

N_p = number of teeth in pinion.

N_g = number of teeth in gear.

ϕ = pressure angle.

Q = ratio factor.

K = load stress factor.

E_1 and E_2 = modulus of elasticity of materials.

S_c = surface endurance limit of ma-material, lb. per sq.in.

F = face width, in inches.

Then:

$$Q = \frac{2\,N_g}{N_p + N_g} \text{ for spur gears}$$

$$Q = \frac{2\,N_g}{N_g - N_p} \text{ for internal gears}$$

$$K = \frac{S_c^2 \sin\phi}{1.4}\left(\frac{1}{E_1} + \frac{1}{E_2}\right)$$

$$W_w = D\,F\,K\,Q.$$

Since W_w is directly proportional to the factor K it is evident that the maximum allowable tooth load, insofar as the ability of a pair of gears to stand

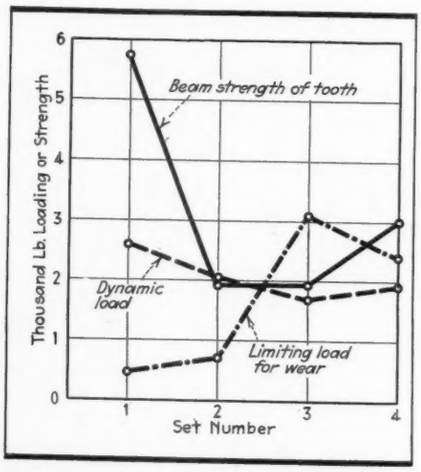
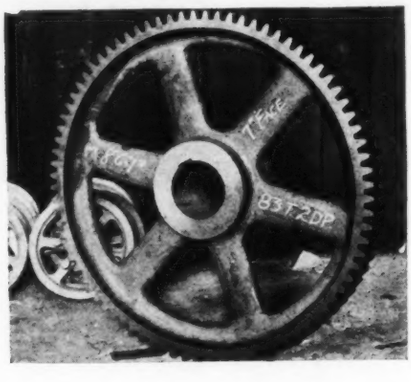


Fig. 1—Graph of the tooth strength and allowable loadings of the gear sets as tabulated in Table II

up against wear is concerned, varies directly as the square of the surface endurance limit of the material, and inversely as the first power of the mean of the moduli of elasticity.

Professor Buckingham gives 90,000 lb. per sq.in. as a value for the surface endurance limit of cast iron. Nickel alloy iron should have a still higher value. Contrast this value with that of steel of 150 Brinell hardness, namely 50,000 lb. per sq.in. Substituting these values along with a modulus of elasticity of steel twice that of iron shows



that a pair of iron gears will have 6½ times the limiting load for wear as a pair made from this grade of steel.

To show the results that can be obtained by the use of alloy iron as contrasted with steel or ordinary gray iron, the values for W_b, W_w, and W_d have been calculated for four different pairs of gears. All pairs consist of two gears both 32 teeth, 4 diametral pitch, 2 in. face, operating at a pitch line velocity of 1,000 ft./min. and transmit a tooth load of 100 lb. All the gears are cut with the same degree of accuracy and have a cumulative error in tooth profile and spacing of 0.002 in. Different materials were selected as follows:

Set No.	Material in Driver	Material in Driven Gear
1	150 BHN Steel	150 BHN Steel
2	150 BHN Steel	Gray Iron
3	Gray Iron	Gray Iron
4	Nickel Cast Iron (A)	Nickel Cast Iron (A)

The results of the calculations are shown on Table II and are plotted on the accompanying chart.

A glance at this chart will show that, since the values for W_b and W_w must be greater than the dynamic load, and since the value of W_b should be at least 1.25 times the dynamic load, the only pair of gears that will work out satisfactorily is Set No. 4, both gears made of alloy iron.

In conclusion it may be said that the use of nickel alloy iron not only increases the beam strength of the gear tooth but also retains to a high degree the inherent physical property of ordinary gray iron which reduces the dynamic tooth load and increases the wear resistance of a pair of gears.

Table II—Allowable Loading for Different Gear Materials

Set No.	*Beam Strength of Tooth*	*Dynamic Load*	*Limiting Load for Wear*
1	5,750 lb.	2,590 lb.	480 lb.
2	1,920 lb.	2,020 lb.	704 lb.
3	1,920 lb.	1,635 lb.	3,088 lb.
4	3,020 lb.	1,920 lb.	2,432 lb.

Question and Comment

Mechanism for Right-Angle Motion

JOHN E. HYLER
Peoria, Ill.

Straight-line motion may be transmitted at right angles by means of the mechanism shown in the accompanying sketch. Unlike a bell crank, this arrangement leaves all of the space within the right angle entirely unobstructed. It is based in some measure upon the geometrical axiom that any inscribed angle subtended by a semicircle must of necessity be a right angle.

The mechanism consists of a flat plate or machine table having a slot machined in it to receive and govern the travel of the reciprocating drive pin, which is connected to a crankpin or other source of reciprocating motion. In line with the slot is a stationary pin upon which the slotted semicircular transmitting member slides and fulcrums, the member being pivotally connected to the drive pin. Provided the points hereinafter mentioned are observed and incorporated, reciprocation of the drive pin within its slot will cause the driven pin to reciprocate in a straight line, thereby obtaining the derived motion at a right angle to the original.

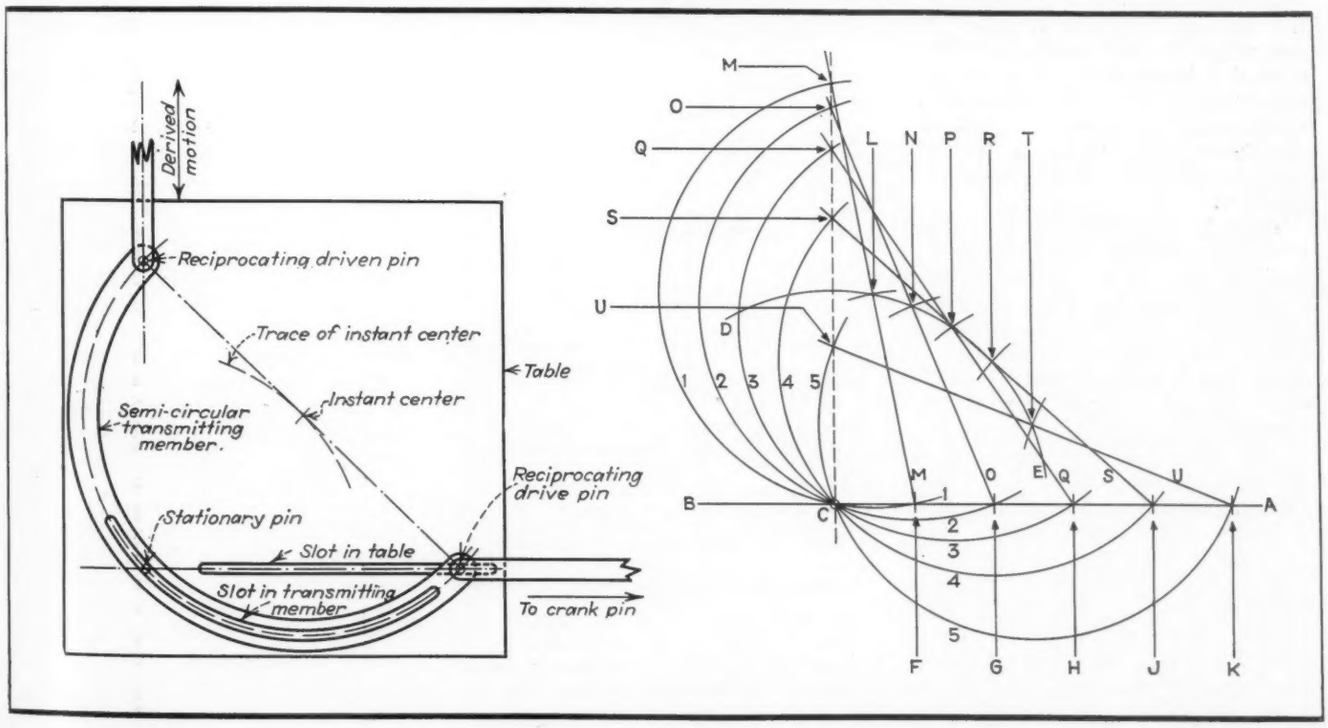
In order to obtain this drive motion, the stationary pin must have its center in line with the center of the slot in the table. In addition, when the mechanism is at rest, an arc struck from the instant center must cut directly through the center of the circular slot in the transmitting member and must also pass through the center of all three pins. Also, the centers of the drive and driven pins must be exactly 180 deg. apart on the transmitting member.

Although the instant center changes position all through the motion, there is one fixed point on the arc of the transmitting member, and that point, of course, is the center of the stationary pin. Therefore, using the radius of the transmitting member and striking an arc from the center of the stationary pin, we obtain the trace of the instant center. Through the use of this trace it is possible to develop the theory and proof of the mechanism.

Referring now to the accompanying graphical analysis of the mechanism, we establish a straight line *AB*, which corresponds to the center-line of the slot in the table. On *AB* we establish an immovable point *C* which corresponds to the center of the stationary pin. With any radius assumed to be the one used, we center on point *C* and strike an arc *DE* which corresponds to the trace of the instant center. Taking a pair of dividers, we step off at random, from *C* along *AB*, a number of points *F,G,H,J* and *K*. These represent points along the slot in the table where the center of the drive pin may be brought to rest during operation. With the same radius, we center on each of these five points and in turn strike a short arc across the arc *DE*, thus obtaining five different instant-center points *L,N,P,R* and *T*.

Still maintaining the same radius, we center on the point *L*, strike an arc *1* which will pass through *F* and *C*, and carry the arc far enough upward to be sure it includes as much as 180 deg. Then we draw a straight line *M* that will pass through points *F* and *L*, producing it to cut arc *1* at the top of the diagram. The same procedure is followed for points *N, P, R* and *T*, using the same radius. On arcs *1,2,3,4* and *5*, the points *M,O,Q,F* and *U* are obtained by

Mechanism for transmitting straight line motion at right angles



laying a straight edge along them, it will be found that they lie in a straight line normal to the path of the drive pin.

The layout reveals another interesting fact. The motion obtained in this manner is either accelerative or decelerative, depending upon the portion of the circular member that is slotted. There is an instant at which the motion is uniform, occurring when the stationary pin is 90 deg. from the drive and driven pins respectively. It is possible, therefore, by manipulation of the mechanism to obtain degrees of acceleration or deceleration that can be adapted to different purposes.

It will be noted that the driven pin may be mounted on a block or confined within slides, or it may be left free as indicated, depending upon the stresses it must meet and upon other conditions such as deflection and chatter. Obviously, a slide-way at 90 deg. from the drive-pin slot will operate with perfect freedom.

More on Gear-Bore Proportions

To the Editor:

The observations of Mr. Shaw as set forth on page 25 of the January issue are very interesting and helpful. However, although he takes exception to my calculation, his own figure proves my point. In support of this contention, I submit these additional comments:

First, Mr. Shaw's initial point is well taken, but his third paragraph has an important bearing on how much the shaft seems to contract.

Second, literally true or not, a key seat or any sharp narrowing section in a member is certainly a point of stress concentration. Strain is not always almost proportional to section area, it also depends on stress distribution. This can easily be seen in a broken tension-test specimen.

Third, if successive pinions were pressed on the same shaft, the shaft fit would be lost, but it is general practice to aim for correct assembly the first time.

Fourth, if some material is used so that the press-fit stress falls between the elastic and yield limits, then shape distortion as well as a useless press-fit allowance will result.

Fifth, machining dimensions are usually given a tolerance which will probably offset Mr. Shaw's hills and valleys, especially on machine-work finish where fits are so small.

Summing up my original remarks, I stated that even a tenth of the stress arrived at as a result of my assumptions would be a dangerous initial stress, and Mr. Shaw arrived at a figure twice as large. He will, I am sure, agree with me that any such initial stress is a dangerous one; the fracture is merely an illustration though, of course, a serious one in itself.

—P. N. BLAND
Vancouver, B. C.

Courtesy Line Omitted

To the Editor:

In looking through the *Product Engineering* for January we notice a cut of one of our photographs showing the pouring of ingots. This appeared on page 19 in connection with the article on "Castings in Design." I presume that you felt it advisable to omit the usual courtesy line because of the nature of the article. As you know, we are, of course, glad to have a courtesy line where possible in cases of this kind.

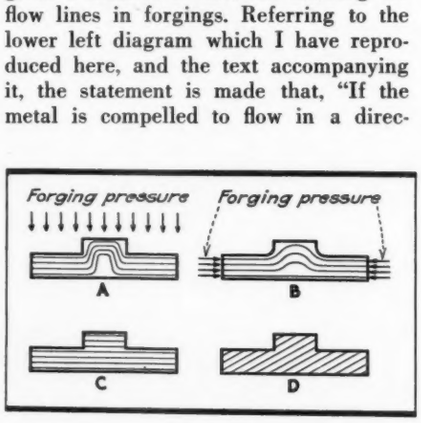
—J. C. LONG
Manager of Publications, Bethlehem Steel Company

[EDITOR'S NOTE—We purposely omitted mention of the courtesy line for fear that it would create the impression that the article had been written by one of the metallurgists or engineers of the Bethlehem Steel Company. This would have given an erroneous impression as the article was written by an engineer connected with another steel company. However, we do wish to take this opportunity of thanking the Bethlehem Steel Company for the use of the picture appearing at the head of the article "Castings in Design."]

Why Forged Bosses Are Stronger

To the Editor:

At the top of page 17 of the January number of *Product Engineering* are given a number of sketches showing the flow lines in forgings. Referring to the lower left diagram which I have reproduced here, and the text accompanying it, the statement is made that, "If the metal is compelled to flow in a direction perpendicular to the lines of the fiber by pressure applied in a direction perpendicular to the grain, as when a boss is raised upon a flat plate and machined, the metal will not be as strong in its resistance to impact loads especially."



The lines indicate the direction of the grain. At A and B are shown bosses produced by forging. Machined bosses are shown at C and D. Relative strengths from greatest to least are B, A, C, D

This is true but it seems to me that the main point has been missed entirely. The striking comparison lies between a boss that has been produced entirely by machining and the fibers running parallel to the plane of the boss. It is merely necessary to consider the flow lines in a forging as having the same effects as the grain in wood. The sketches given here tell the whole story.

—L. L. LAWSON
New York, N. Y.

[EDITOR'S NOTE—Mr. Lawson does not mention the last sentence in the caption under the illustration at the top of page 17, namely, "The worst condition is a boss that is machined across grain." Evidently that brief sentence was insufficient to carry across the idea. Mr. G. T. Williams who contributed the data also suggested a more complete explanation but his request reached us too late.]

Sealing Ceramics to Metals

SAMUEL WEIN
New York, N. Y.

There recently appeared in *Product Engineering* an inquiry from a reader desiring information on uniting ceramics and metals. Herewith follows an outline of the steps necessary to deposit metal on the surface of glass or ceramics and subsequenty uniting them to form one solid piece.

1. The surface is coated with a thin film of the "metal paint" which is fused into it at elevated temperature, forming an intimate bond between the ceramics and the deposited metal.

2. The thin metal film can then be increased in thickness by electroplating.

3. The two pieces of glass or ceramic with the films of metals are now soldered with either silver solder or are sweated together by any one of the common processes now practiced.

4. The joined surfaces are then finished by further electroplating and subsequently polished to give the finish desired.

For "silver paint" the following formula is in general use: silver chloride, 4 oz.; boracic acid, 4 dwt.; potassium nitrate, 4 dwt.; flint powdered flint, 4 dwt.; powdered glass, 4 dwt.; soda ash, 4 dwt.; lead oxide, 4 dwt.; borax (calcined), 8 dwt. These ingredients are ground to a fine powder in a mortar and pestel or in a pebble mill to a fine powder in order to avoid

possible lumps in the deposited film of silver.

A little of the ground powder is mixed with oil of lavender to a consistency of a thin paint. Mixing is best done on a flat ground glass with a spatula and only enough is mixed as is required for immediate use as the mixture decomposes rapidly. The paint is then applied over the surface with a fine badger's or camel's hair brush.

After drying for several hours, or preferably over night, away from dust and sudden air drafts, the coated material is subjected to the firing process. Definite instructions cannot be given since the firing depends upon the nature of the material and the paint which has been applied. Experience has shown that the firing temperature is "a dull red heat" in the oven. After the temperature has been attained, it is gradually reduced, the material being allowed to remain in the oven over night. After the material is taken from the oven it it slightly scratch brushed to remove the crust of silver oxide. The electrical contact is made and the part hung in a plating bath in order to thicken the film of metal by electroplating more silver upon it. This increases the mechanical rigidity of the joint.

Instead of silver, metallic gold paint or platinum paint might be used.

Calculating Gear Centers

To the Editor:

I was very much interested, and somewhat amused, to read a letter by Hans Schemm, published in your December issue, relating to the solution of a dimension problem.

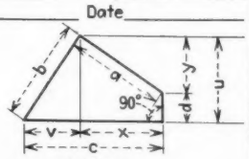
I am enclosing one of our standard forms for this calculation. We fill out this form, using a 10-place electric computing machine, supplemented with Barlow's Tables of Squares, etc., for the approximate square roots. Although the calculations are carried to ten figures, this is not necessary, and is done only to get a more accurate check. You will notice that a check is furnished at the end of the calculation. The example given here was computed in twelve minutes.

— W. B. JORDAN
Schenectady, N. Y.

GEAR CENTER CALCULATION

Location_____ Req._____
Draftsman_____ Date_____

a=6.25
b=4.625
c=5.445
d=9.375



$Q=a^2=$	39.0625
$R=b^2=$	21.390625
$M=c^2+d^2=$	117.53865
$N=\frac{1}{2}(M+Q-R)=$	67.6052625
$x=\frac{1}{M}(d\sqrt{QM-N^2}+cN)=$	3.49630890
$v=c-x$ or $-c+x=$	1.9486911
$y=\sqrt{Q-x^2}=$	5.18057179
$u=-y+d$ or $(y+d)=$	4.19442821
$0=u^2+v^2-R=$	0.012×10^{-7} Check

Calculated by_____

Form used for calculating the location of the gear center. Using an electric computing machine, the work can be done in about twelve minutes

Sources of Supply Wanted

Here are a number of inquiries that some of our readers may wish to answer. Letters received in reply will be forwarded to the individuals desiring information on the subject, and abstracts of the letters will be published in subsequent issues.

Inbuilt Lighting Unit

To the Editor:

As part of a compact drill press now being designed, we would like to incorporate a small lighting unit for the purpose of providing supplementary illumination on the work. The unit must be neat-appearing and adaptable to so-called "designed-in" or "inbuilt" assembly.

These requirements—somewhat special, we admit—seem to fall within a field of product design which has not been developed as yet to a point where our needs can be fulfilled for, although we have written a number of manufacturers, we have not found an adequate source of supply.

If any of your readers has a suggestion to offer, we would certainly appreciate his comments. —B.P.E.
Milwaukee, Wis.

Scanning Device

To the Editor:

It is our idea that we can find a device which would permit a textile printing machine operator to scan a moving web of cloth which had been printed in several colors. The web of cloth is considerably above his head, and moving at an angle away from the operator. It was our thought that there is perhaps a device which would scan the cloth and throw an image on a mirror placed in such a way that the operator could see the design on the cloth very easily. Naturally if the speed of the cloth could be stepped down by means of the stroboscopic device, it would be easier for him to check the pattern, and know whether his rolls were properly set. Is such a device available? —G.A.F.
Paterson, N. J.

Manufacturer Wanted

To the Editor:

Will you be good enough to supply us with a list of the names and addresses of manufacturers of high-class precision instruments who will be in a position to quote on the manufacture of a high-class electric camera for use in professional photography, the manufacturer to produce the camera only without lens.
—F.H.B.
New York, N. Y.

Can You Work This One?

H. E. SMITH

This Month's Problem—

Telephone Poles

On two parallel streets there were the same number of telephone poles, each of which was to have a crossarm put on it. Two linemen, Joe and Frank, were assigned to the work. They planned to start the job the next morning and drew lots to see which street each would work on. Joe arrived first the next morning and had already finished three poles when Frank got there and informed him that he had been working on the wrong street. Joe then started on the other street and Frank began with the next pole. Frank finished the poles on his street before Joe, then came over and began working on the other end of Joe's street, and had finished the six last poles there when Joe got to that point. How many more poles in all did Frank put crossarms on than did Joe?

Solution to Last Month's Problem—

Watch Chain

To cut the 60-link chain as few times as possible and be able to pay his boarding house bill with one link each night, the financially embarrassed boarder cut links number 5, 14 and 31. This gave him three single links, the ones which were cut. The first group contained 4 connected links, the second group 8, the third group 16, and the fourth group 29 links. In this way he could make change for 60 days, that is, deliver one additional link to his boarding house mistress each night.

DESIGN OPLA

A few pointers illustrating ways to improve designs of molded parts that make molding less difficult, save material and shorten curing time; they also improve the appearance of the product

F. W. WARNER
Product Engineer, General Electric Company

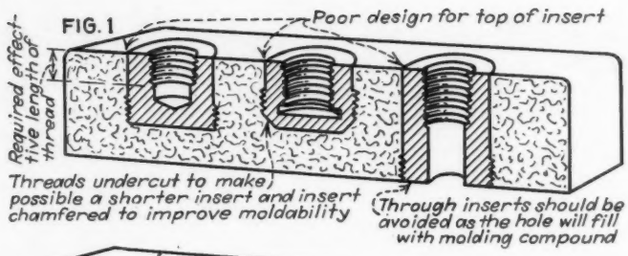


FIG. 1
Poor design for top of insert
Required effective length of thread
Threads undercut to make possible a shorter insert and insert chamfered to improve moldability
Through inserts should be avoided as the hole will fill with molding compound

FIG. 1—Inserts in molded plastic pieces should be carefully designed to prevent the molding compound from entering threads. Outer faces of inserts if flush with the surface of the molded part unless in perfect alignment offer an opportunity for molding compound to flow into spaces not tightly sealed. Inserts should be as short as possible and chamfered to reduce possibility of displacement during molding.

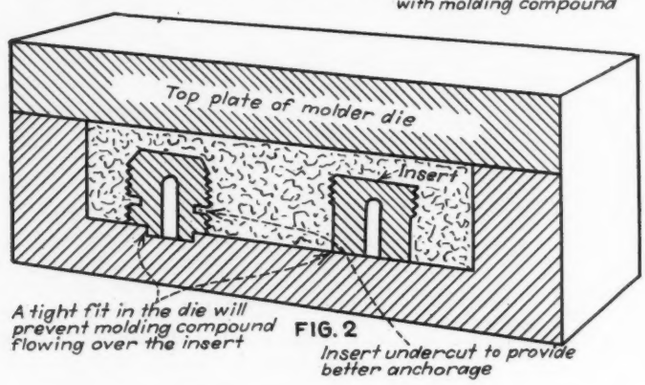

Top plate of molder die
Insert
A tight fit in the die will prevent molding compound flowing over the insert
FIG. 2
Insert undercut to provide better anchorage

FIG. 2—Designing the mold with a recess which holds the insert tightly will prevent the molding compound flowing over the insert when molding pressure is applied.

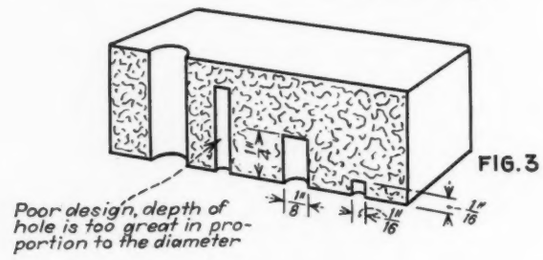


FIG. 3—Holes are easier to mold if they go all the way through a molded piece. Core pins for through holes can be piloted into and be supported by holes in either half of the die. Holes not going all the way through should be limited to a depth of twice the diameter. Small holes 1/16 in. or less in diameter should not be deeper than the diameter.

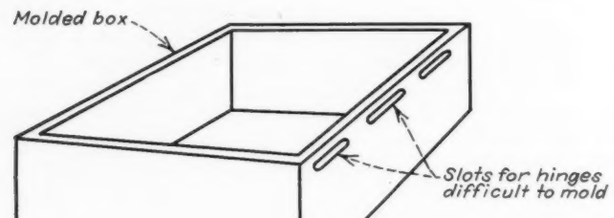
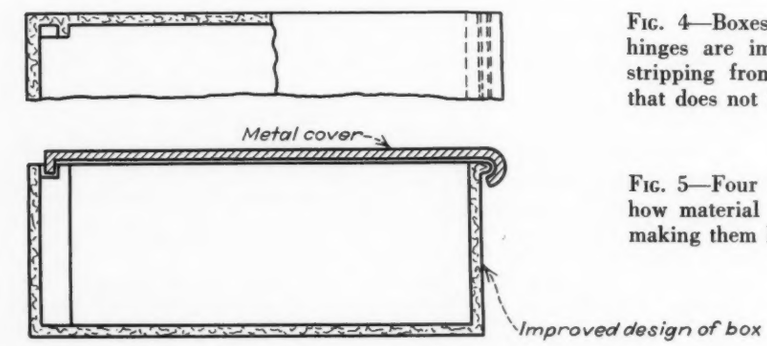


FIG. 4—Boxes designed with slots in the sides for cover hinges are impractical because of difficulties involved in stripping from the mold. An improved design is shown that does not involve any molding difficulties.



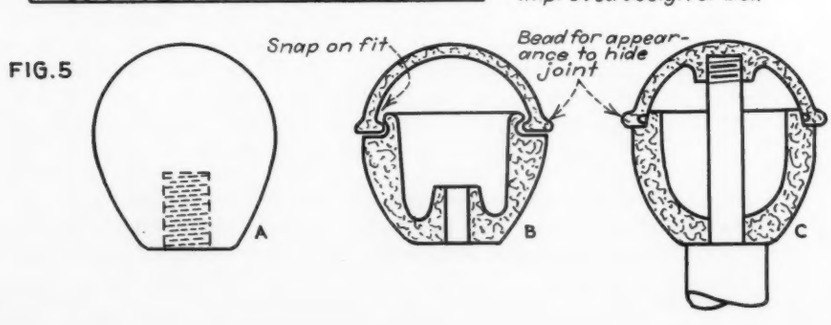


FIG. 5—Four designs of molded balls or knobs, showing how material can be saved and curing time shortened by making them hollow as in B, C and D.

PLASTIC MOLDED PARTS

FIG. 6—High rejection percentages can be caused by the raising of blisters or the formation of dimples at heavy sections after the piece has been removed from the die. Variation in flow of the material caused by a change of volume in cavity can result in a streaked or rippled effect and also warping.

FIG. 7—Design A costs more because it cannot be cleaned by tumbling which might break off the lug. By adding a reinforcing rib as shown at B the lug is greatly strengthened and it can withstand tumbling shocks without breaking.

FIG. 8—Thickness of material between an insert and the wall of a hole should be at least 1/32 in., and between holes the thickness should be at least 1/16 in. so that the molding material can flow and fill properly before setting, and for strength of tool.

FIG. 9—Method of molding a hole at right angles to direction of draw in side wall of an interior hub or wall.

FIG. 10—For long holes of small diameter a two-piece construction can be used to avoid long slender core pins. Inner piece is cold when inserted in warm outer part. Tight shrink fits are readily obtained since the outer part will shrink after being assembled to inner part.

FIG. 11—Design for a handle made of two molded halves. Advantages obtained in use of this design are: saving in compound and more rapid production since less curing time is necessary.

FIG. 12—Unsightly parting lines can be hidden by throwing up a bead at the joint so that they form a part of the appearance design. A bead also permits the part to withstand cleaning by tumbling without scratching.

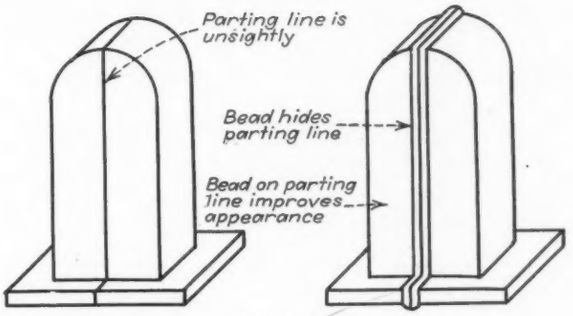


FIG. 12

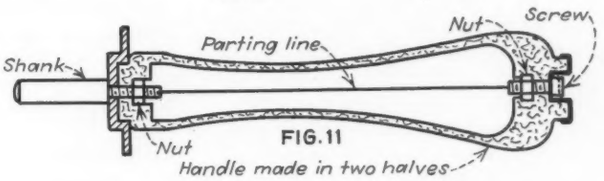


FIG. 11

Handle made in two halves

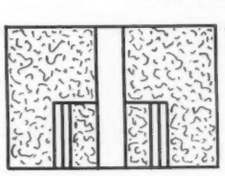
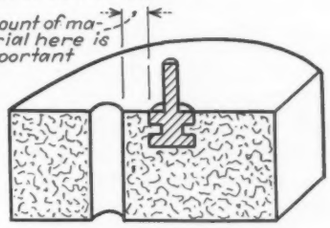
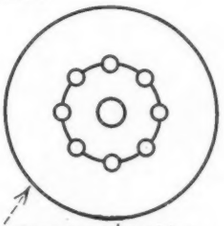
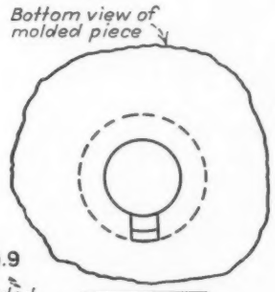



FIG. 10

FIG. 8





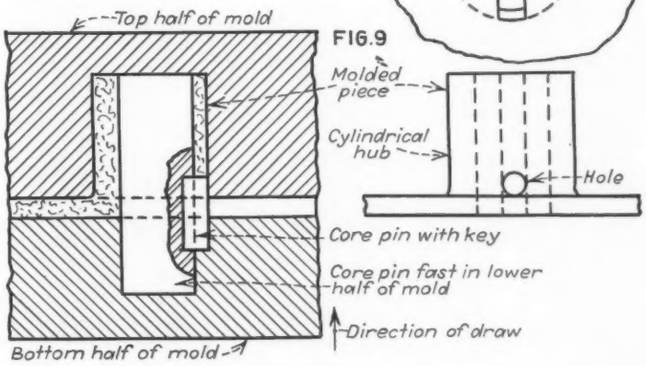


FIG. 9

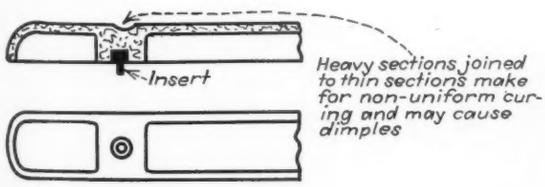
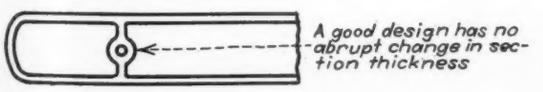
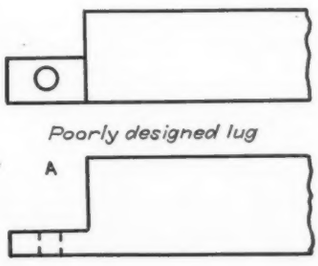


FIG. 6





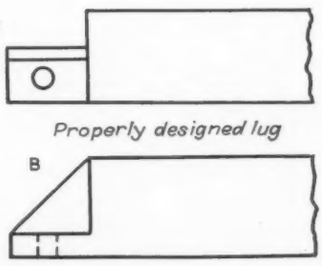


FIG. 7

News

Research Fellowship at Mellon Institute

DR. EDWARD R. WEIDLEIN, director of Mellon Institute, Pittsburgh, Pa., has announced the establishment of an industrial fellowship by the Westinghouse Electric & Mfg. Company for the study of problems in the field of dielectrics and electrical insulation. Dr. Robert N. Wenzel, a member of the Mellon Institute research staff since 1927, has been appointed fellow in charge of this project.

Dr. Wenzel is a graduate of the chemical engineering department of Stanford University, where he later held appointments as instructor in the department of applied mathematics and in chemistry while engaged in research on reactions in liquid ammonia under the late Dr. E. C. Franklin. Before coming to Mellon Institute, Dr. Wenzel had previous industrial research experience in smelter smoke investigations for the American Smelting & Refining Company at Tacoma, Wash., and Salt Lake City, Utah, and in the vapor-phase oxidation of naphthalene to phthalic anhydride at the St. Louis plant of the Monsanto Chemical Works. At Mellon Institute he has been engaged in physicochemical studies relating to the manufacture of commercial fatty acids, the kinetics of vapor-phase gum formation in coke-oven gas systems, and the application of sulfonated oils, waxes and other fatty derivatives as textile finishing agents.

The dielectrics fellowship has as its general objective the development of improved insulating materials and processes for application to equipment of Westinghouse manufacture, and it brings the facilities of Mellon Institute into cooperation with those of the Westinghouse Research Laboratories at East Pittsburgh in insulation research.

Beryllium Copper Will Sometimes Spark

ACCORDING to information received from The Riverside Metal Company, under certain conditions beryllium copper is not absolutely non-sparking, in spite of the fact that such a statement was made in their recent booklet. In explaining the situation The Riverside Metal Company states, "We have just been advised that under certain conditions beryllium copper is not absolutely non-sparking. In the interest of safety, we are bringing this to your attenion. Any statements in our recent booklet to the contrary must not be relied upon, especially in the first paragraph on page ten and the last paragraph on page five of the Revised Edition, May 1937 booklet."

No further details are available as to the conditions under which beryllium copper will cause sparks.

New Hardening Method Keeps Steel Ductile

ORDINARY steel can now be made almost hard enough to cut glass yet so ductile that it can be bent double, according to Edmund S. Davenport, physical metallurgist of United States Steel Corporation, who, in collaboration with E. C. Bain of the same company, developed this process.

Speaking before the New York Electrical Society, Mr. Davenport explained that the essence of the process is the quenching of the steel into a bath of molten substance instead of water or oil and holding it there for a predetermined period. The quenching medium used is molten lead, salt or any substance capable of withdrawing heat quickly from the steel without combining chemically with it. Depending upon the temperature of the bath and the composition of the steel, the steel undergoes certain transformations, the time element being a factor. In general, the lower the bath temperature, the higher will be the strength and hardness and the lower will be the ductility of the steel. Likewise, the lower the bath temperature the longer will be the time necessary to complete the transformation, although there may be certain exceptions to this rule.

Describing the scientific aspects of this phenomenon, Mr. Davenport stated that when steel is cooled rapidly, as in water quenching, it tends to transform to the hard so-called "martensitic" condition which makes it brittle. But in austempering, as this new patented process is called, the steel is quenched in such a manner that the formation of hard, brittle martensite is avoided, thereby resulting in an unusual combination of high hardness and ductility with accompanying improved impact strength.

At present, austempering of plain carbon steels is limited to sections which can be cooled rapidly. If too thick, heat cannot be withdrawn from the steel rapidly enough to cool it to the austempering bath temperature. Experience has indicated that the upper limit thickness of carbon steel which can be successfully austempered lies somewhere between ¼ and ⅜ of an inch.

Suggested uses for this new process include the austempering of garden tools, shovels, chisels and all manner of springs.

Metal Power Products Division Organized

HANDY & HARMAN announce the formation of a Metal Powder Products Division which, as the name indicates, will engage in the development and manufacture of products which are fabricated from metallic powders. This division is the result of several years of research with metallic powders during the course of which processes have been developed for the manufacture of a series of workable powder compositions designed for specific electrical applications in the form of sheet, strip and wire. Gregory C. Comstock has been appointed manager of this department.

Studebaker Chosen As Best Designed Car

THE *Magazine of Art*, official publication of the American Federation of Arts, had designated the 1938 Studebaker as the "best designed car of the year." In the article explaining the selection of the Studebaker as the best design, special recognition is given to Raymond Loewy, industrial stylist, who served as consulting engineer and from whose designs the Studebaker engineers developed the 1938 model.

According to the article, "Studebaker brings out the car of the year and the best looking model in its history. Raymond Loewy shaped the exteriors and Helen Dryden designed the harmonious interiors. We choose it as the car of the year because it is pleasantly clean in outline, the curves of fender and top and trunk playing against each other well. The effect, furthermore, is not marred by fussy treatment of chromium

details. The sides of the hood are free from unnecessary louvres. A narrow metal line flows back continuously from the radiator to the rearmost window. All in all, even though it is not unconventional in its basic shape, the Studebaker looks like a machine for traveling. Nothing interferes with that impression. That's why Raymond Loewy has succeeded so well."

Road Builders' Show

Thousands of engineers who visited the exposition of road building machinery at Cleveland, Ohio, during the week of January 17-21, were rewarded with a splendid opportunity to see firsthand the recent developments in the design of machinery in this field.

Prominent among the many exhibits were power plants mounted on separate chassis supported on wheels or skids, both gasoline engines and diesels are employed as prime movers. Connected directly to these engines are electric generators, air compressors or hydraulic pumps for supplying power to the independent road building unit for operating dumping, digging, turning or swinging elements by means of hydraulic motors, hydraulic or air cylinders.

Gallonage Tables for Cylindrical Tanks

TABLES by which the gallons content of flat-ended horizontal cylindrical tanks of various diameters at different depths can easily be obtained have been made available by the Bureau of Standards, Weights and Measures Division. Prepared by E. L. Peffer, the tables give the volume in gallons of a section 1 in. long, for tanks of various diameters filled to various depths. Thus the total volume for a tank filled to a given depth can be obtained readily by multiplying the tabulated figure by the inside length of the tank in inches.

This publication, Circular C416, can be obtained for five cents a copy from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Study of Color Values

A REPORT on a study of the specific values of color in advertising made by the Gallup Research Service for the Wrenn Paper Company of Middletown, Ohio, reveals some highly interesting facts. In order to determine the relative values of colors in stimulating the memory, blotters all of the same design were printed in ten different colors and distributed to each of ten different sections of the city of Chicago. A record was kept of the color of the blotter left with each recipient, thereby enabling the investigator to know in advance what color had been received. A week after this distribution the investigator went into the field to interview the business men and housewives who had received the blotters. A number of questions were asked, the answers to which indicated the extent of the impression made by a blotter.

Summarizing the results of this investigation, dark blue has the most pronounced advertising value on the women and dark green the least. Violet has the most pronounced advertising value on the men and dark green the least. According to the figures dark blue may be considered as having by the women five times the stimulation possessed by dark green in its influence on memory stimulation, while for men violet gave an advantage of 42 per cent over the average of the other colors used and 70 per cent over the least effective color, which was dark green.

One surprising result indicated that men are 8 per cent more responsive to average colors than women and 20 per cent more responsive to their most effective color. In summarizing the results of the investigation The Wrenn Paper Company emphasizes that color is no "open sesame" by which the advertiser simply tints his message and then sits back to watch the orders pour in. Certain colors more than others enhance the advertising power of a message. Perhaps the same general statement could be made with reference to the application of color to manufactured products.

MEETINGS

WELDING CONFERENCE—*7th Annual Welding Conference, Industrial Engineering Bldg., Ohio State University, Columbus, Ohio. Feb. 24–25. O. D. Rickly, chairman, Welding Conference Committee, Ohio State University, Columbus, Ohio.*

SOCIETY OF AUTOMOTIVE ENGINEERS—*National Aeronautic Meeting, Mayflower Hotel, Washington, D. C., March 10–11. John A. C. Warner, secretary and general manager, 29 West 39th St., New York, N. Y.*

AMERICAN MANAGEMENT ASSOCIATION—*8th Packaging Exposition, Palmer House, Chicago, Ill., March 22–25.*

SOCIETY OF AUTOMOTIVE ENGINEERS—*National Passenger Car Meeting. Hotel Statler, Detroit, Mich., March 28–30. John A. C. Warner, secretary and general manager, 29 West 39th St., New York, N. Y.*

AMERICAN GEAR MANUFACTURERS ASSOCIATION — *22nd Annual Meeting, General Brock Hotel, Niagara Falls, Canada, April 18–20. J. C. McQuiston, secretary, Penn-Lincoln Hotel, Wilkinsburg, Pa.*

New Publication on Photoelasticity

A. G. SOLAKIAN, lecturer at Columbia University, has announced the forthcoming publication of a new magazine under the name of *Photoelastic News*. This monthly publication will deal with stress determination and other applications of polarized light and the materials used in photoelastic investigations.

The contents of the first number of the magazine includes articles on plastics used in photoelasticity, photoelastic models with cemented elements, stress-strain relations, polarized light and applications and an article on the historical development of photoelasticity.

A. G. Solakian is editor. The magazine is published by Polarized Light Company, 55 West 42d Street, New York, N. Y., and the subscription price is $2.00 per year.

Do You Know That—

A TAP of solid cemented carbide for use on unfired porcelain tapped 70,000 holes without regrinding, indicating an estimated life of 280,000 holes. High-speed steel taps on the same service give about 250 holes per grind and a total of 1,000 holes per tap. (69)

SPECIAL ALLOYS developed for vibrating screens are so hard that they are difficult to file and will resist grinding and scouring, even under wet conditions, but are not brittle. Their toughness is ample to withstand loads and impacts. (70)

BERYLLIUM COPPER washer type intake valves, 2.74 in. O.D. x 1-13/16 in. I.D. x 0.020 in. gage thickness, have stood up remarkably in tests running over 1,000 hr. The valves were blanked from sheet 4 B&S numbers hard, followed by the usual heat-treatment and indicated a wear resistance approximately three times greater than saw steel. (71)

A FLUORESCENT chalk which glows with a strong green light and is visible at a distance, has been developed recently. Under normal light it appears like ordinary chalk. One use is for making notes on blackboards during the showing of moving pictures. (72)

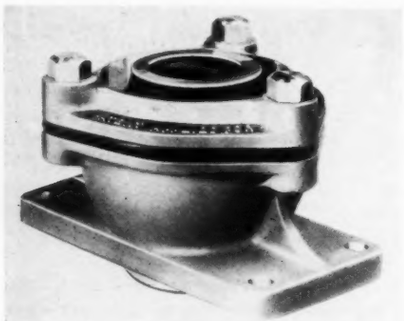
GLASS MARKING inks in both black and white which adhere to the surface when applied with a steel pen and are set by the application of only a moderate temperature are available. (73)

THIN STAINLESS sheets cemented to a flexible backing are now available. (74)

New Materials and Parts

Flexible Stuffing Box

A completely flexible, full-floating, self-adjusting and self-lubricating stuffing box, developed for marine applications. Unit consists of a cushioning element clamped between the outer housing and the flange by means of three cap-screws. In the bore of the cushioning element are mounted a rear bushing and three packing rings with separators that are held against the rear bushing by means of a helical spring, the other end of which bears against the front bushing which is held in place by a snap ring. The unit accommodates a momentary



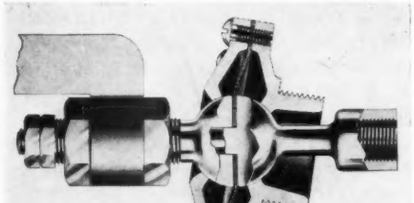
angularity of 20 deg., 10 deg. in each direction, and from 3/16 to 3/8 in. extreme intermittent eccentricity. It also muffles noise, cushions whip, absorbs shock and dampens vibration by virtue of the composition cushioning element. Available in shaft sizes ranging from 1 to 1-3/8 in. in diam. with either standard flange or threaded flange. Federal-Mogul Corp., 309 Shoemaker Ave., Detroit, Mich.

New Plastic Material

A thermoplastic material called Bakelite Polystyrene which is claimed to possess a loss factor of less than 0.00053, a power factor of less than 0.0002, and a dielectric constant of 2.60 at 60 cycles, 1,000 cycles and 1,000,000 cycles. Dielectric strength is more than 500 volts per mil; resistivity 10^8 megohm-centimeters; and arc resistance is 240–250 sec. It is claimed temperature or humidity do not affect its electrical properties. It is said to be free from crazing, has permanence of dimension, and high resistance to water, acids and alkalies. A.S.T.M. impact strength is 0.16 to 0.20 ft. lb., flexural strength 7,000 lb. per sq. in., and tensile strength 5,000 lb. per sq. in. Bakelite Corp., 247 Park Ave., New York, N. Y.

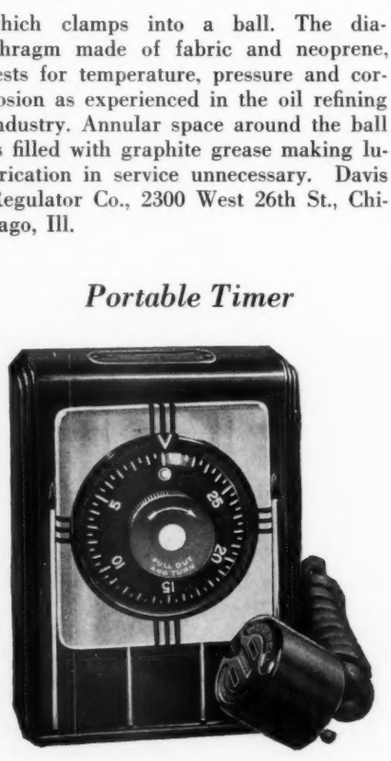
Packless Transmission Unit

Developed primarily for float boxes and lever-operated control valves, this transmission unit has a center diaphragm made of fabric and neoprene,



which clamps into a ball. The diaphragm made of fabric and neoprene, tests for temperature, pressure and corrosion as experienced in the oil refining industry. Annular space around the ball is filled with graphite grease making lubrication in service unnecessary. Davis Regulator Co., 2300 West 26th St., Chicago, Ill.

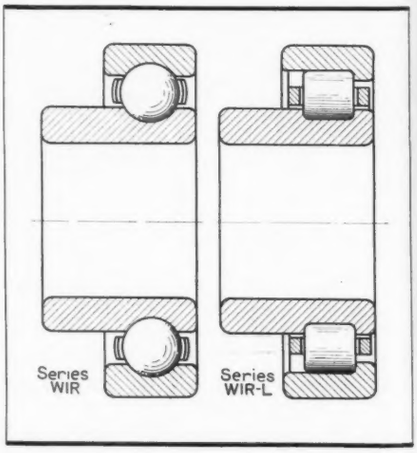
Portable Timer



A new portable timer for general utility use. The improved switch mechanism utilizes the cone-center principle and provides immediate closed circuit settings for even the shortest interval. The timer is mounted in a molded black case with nickeled face plate and decorations and is equipped with rubber covered cord and series wired plug. When the appliance is to be operated for any predetermined period the timer dial is pulled out and set for the interval desired. This closes the timer switch circuit and places the appliance into operation for the set interval, at the end of which the timer circuit opens and appliance operation ceases until the dial is set for another interval. Available in 15, 30 and 60 min. maximum timing ranges. Switch capacity is 15 amp., 125 volts, a.c. and d.c. Walser Automatic Timer Co., Graybar Bldg., New York, N. Y.

Precision Bearings

Two new types of precision bearings, the WIR Series of ball bearings and the WIR-L Series of roller bearings, having a wide inner ring of double-row bearing width in combination with an outer ring of single-row width. Designed primarily for opposed mounting in electric motors and similar equipment. The wide inner ring insures a better sealing on the shaft and in many cases avoids the necessity for threading the shaft and applying lock nuts or other locking devices. This elimination of threads permits a larger shaft extension diameter for a given bearing bore and avoids weakening of the shaft by threading. WIR ball bearings are available in the medium metric series, from 25 to 55 m/m bore. WIR-L cylindrical roller bearings with one-lipped outer ring are available in the medium metric series, from 30 to 130 m/m bore. Norma-Hoffmann Bearings Corp., Stamford, Conn.

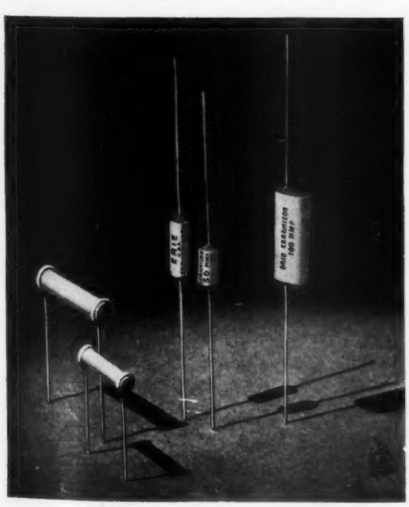


Mercury Switch

A new design of switch in which the contact is made and broken by the movement of mercury. The switching element, about the size of a small coat button, is composed of two metal disks sealed with glass, completely inclosing the mercury make-and-break of the switch. During a two-year laboratory life test the switches were claimed to have operated more than 65 million times without failure. Large binding screw heads accommodate number 12 wire. Switch can be installed in any standard switch box and must be mounted vertically. Casing and handle are of Textolite. General Electric Co., Bridgeport, Conn.

Small Fixed Condensers

Three types of fixed condensers, known as Erie Ceramicons, consisting of a ceramic dielectric with coated plates of pure silver fired on at a very high temperature. The units are inherently stable in capacity, a change of less than ¼ of 1 per cent will be found after 600 hr. alternate heating and cooling from 40 deg. F. to 250 deg. F. Increase in power factor is less than 20 per cent and change in capacity is less than ¼ of 1 per cent after 100 hr. of at 100 per cent humidity, 40 deg. C. Capacity is independent of frequency. By combining one type having a definite positive temperature coefficient with another having a definite negative temperature coefficient, any temperature coefficient between the limits of the two individual units may be obtained. The units are conservatively rated at 500 volts d.c. Erie Resistor Corp., 644 West 12th St., Erie, Pa.



Metal Finish for Rubber

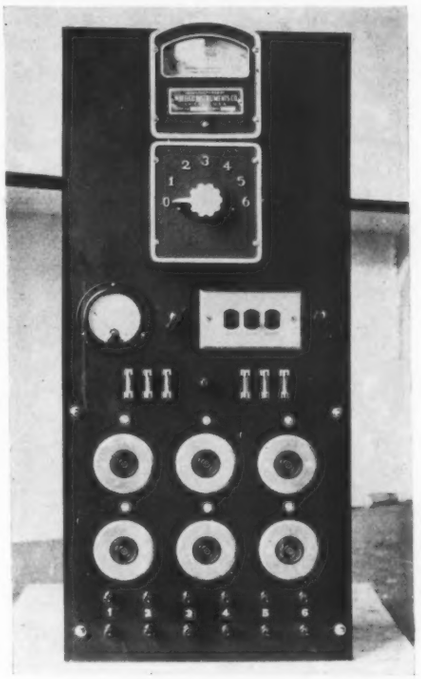
A special bronze lacquer for rubber, providing a strongly adherent, durable finish resembling brass, copper, bronze, aluminum, steel, or other metal. It consists of a special bronzing liquid to which metal powder of any kind is added prior to use. The mixture is applied by spraying and air-dries rapidly. Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.

Explosion-Proof Motor

A line of explosion-proof squirrel-cage a.c. motors, Type AA. All working parts are completely inclosed and the housing is claimed to be strong enough to withstand even an internal explosion without bursting, loosening the joints, or permitting flame to escape into the outside air. Rotors are integrally cast to assure reliability and uniformity of performance. Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland, Ohio.

Utility Test Panel

Designed for testing electrical household and portable appliances. Six separate devices may be put on test at one time and a complete set of readings taken for each device separately. The surface temperature or internal temperature of any device can be measured up to 800 deg. F.; the resistance of any device from 0 to 1,000 ohms can be measured directly; and continuity current readings can be observed on the milliammeter as low as 10 milliamperes. Test prods are provided to enable the user to check the resistance of any unit or any part of unit circuit; also to determine the resistance from element to ground on any device. Wheelco Instruments Co., 1929 S. Halsted St., Chicago, Ill.



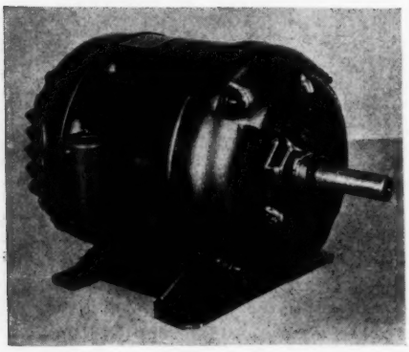
A. C. Across-the-Line Starter

Known as NEMA size 0, for use on polyphase squirrel cage motors. Special features of this new, compact starter are "pushbutton" operation; positive quick make and break "twin-break" mechanism; silver-to-silver contacts; three and four-pole construction; C-H eutectic thermal overload protection, free tripping type; rubber mounted operating mechanism, removable without disturbing the conduit; and an aluminum interior finish which provides maximum visibility. The starter is interchangeable for all horse-

power sizes within its rating by changing the thermal overload coils. Measures 4¾x8 in. and is rated up to 2 hp., 550 volts. Cutler-Hammer, Inc., 296 N. 12th St., Milwaukee, Wis.

Repulsion-Induction Motor

An improved line of integral-horsepower repulsion-induction motors, Type RG, for operating air compressors, viscous liquid pumps, refrigerant compressors, conveyors, etc. Special features include high starting torque, low starting current, positive starting on low voltage, high power-factor. Available in sizes 1 to 3 hp., in vertical and horizontal types. Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.



Pneumatic Transmission System

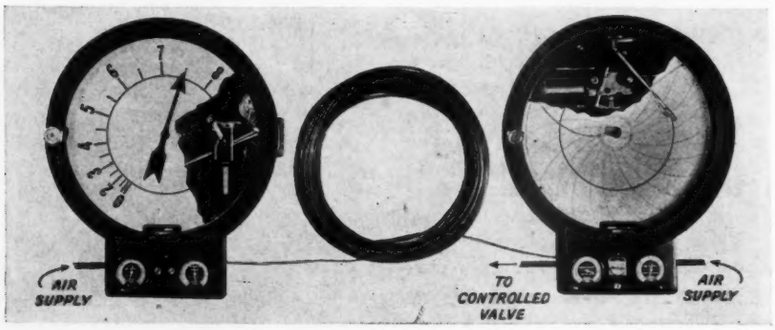
Designed primarily for remote measurement of process variables in atmospheres containing explosive gases, where electrical measurement is not permissible. Consists essentially of a transmitting indicating instrument, at the point of operation, and a receiver located at the remote master control board. The remote transmission unit is a simple, balanced air pilot, mechanically actuated, built into the indicating transmitter. The receiver is either an indicating or recording pressure gage, calibrated in terms of the variables being measured. Recalibration or compensation is not necessary when a transmission line is lengthened or shortened. The Brown Instrument Co., Philadelphia, Pa.

Thermostat Control

Thermostat with the control knob and scale plate removed from the outside of the inclosing case so that adjustments must be made by first removing the cover. Absence of the usual control knob removes temptation of tampering with the setting of the instrument. Jefferson Electric Co., Bellwood, Ill.

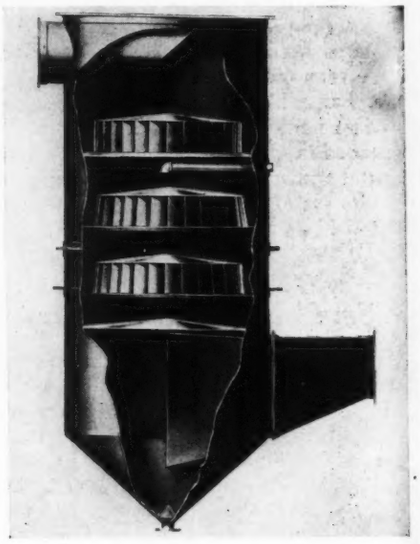
Round-Chart Pyrometer

This new potentiometer pyrometer for recording and indicating thermocouple temperatures has a dial for the scale indication. Operating mechanism consists of a dampened sensitive galvanometer, pivoted in jewel bearings; a relay unit actuated by the galvanometer to operate the motor that balances the electromotive force and positions the recording pen arm and scale indicator; a standardizing unit; a "power pack"; and the potentiometer or recording and indicating units. There is no mechanical motion of any kind except when a change in temperature occurs. No lubrication is required. The Bristol Co., Waterbury, Conn.



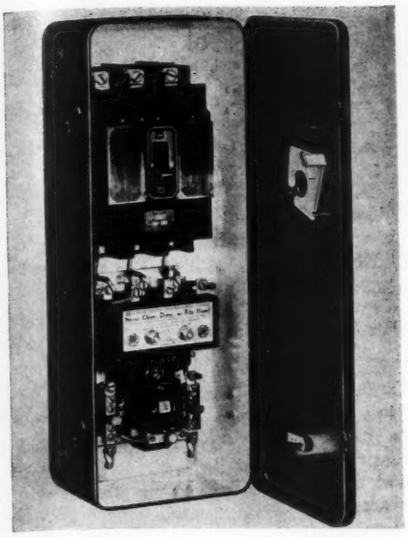
Junior Multi-Wash Dust Collector

Designed primarily for single function operations such as pulverizers, spray booths, molding stations, sand conditioning units, packaging machines, driers, grinders, etc. This new Junior model possesses the same major operating advantages as the Senior model except that dirty air, gases, or fumes are scrubbed five times by the impingement plate arrangement instead of thirteen times as in the larger unit. The Junior model can readily be converted into the Senior model by inserting a single section in the tower containing the necessary additional impingement plates. The Claude B. Schneible Co., 3951 Lawrence Ave., Chicago, Ill.



Starting Switch

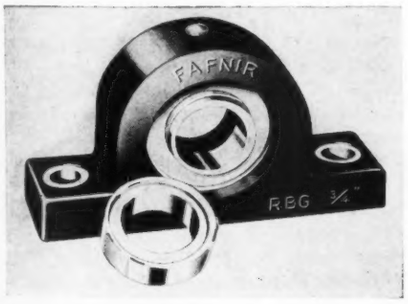
A new combination starting switch utilizing circuit breakers, known as the Bulletin 713. The automatic starting switch is of the solenoid type, with double break, silver alloy contacts and two thermal overload relays. The circuit breaker is inclosed in a molded plastic case and has three poles operated by a single lever. It can be tripped open or closed in the same manner as an ordinary disconnect switch. An overload in any pole trips a bimetal thermal unit and opens the breaker. All poles are also equipped with an instantaneous magnetic trip. The "resisto-therm" relays on the automatic starter affords protection against sus-



tained overloads. Short circuit protection is provided by the bi-metal and magnetic trips on the circuit breaker. The units have a maximum rating of 30 hp., 220 volts; 50 hp., 440–550 volts. Allen-Bradley Co., 1311 S. First St., Milwaukee, Wis.

New Rubber Pillow Block

Available with a grease fitting for out-of-the-ordinary conditions, permitting frequent lubrication with the least amount of trouble. The molded rubber housing eliminates any slight bearing noise and compensates for partial misalignment or longitudinal shaft expansion. The Fafnir wide inner ring ball bearing with self-locking collar provides an exceptional degree of shaft support as well as ease of installation and disassembly. This new pillow block is especially suitable for air-conditioning and ventilating equipment. The Fafnir Bearing Co., New Britain, Conn.

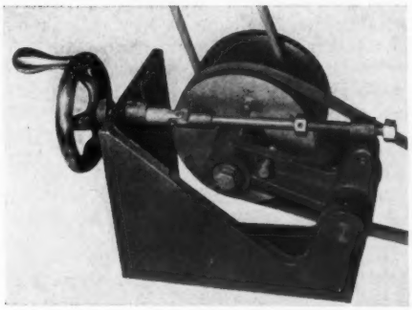


"Insulag" Refractory Lagging

Designed for use on high-temperature equipment. May be applied on hot or cold surfaces of flues, ducts, drums, etc.; also on refractory brick and concrete, and as a finishing coat for other insulation. It is claimed that this material does not shrink when drying, but actually increases in thickness after application and retains this increased volume throughout its entire range of service temperature. It has low-heat storage and low thermal conductivity properties, which permit reduction in thickness of heavy fire-brick walls. Crushing strength, when thoroughly dried, is in excess of 150 lb. per sq.in. It is recommended for interface temperatures up to 2,200 deg. F., or directly exposed to 2,000 deg. F. The material sets quickly with or without heat. Quigley Co., Inc., 56 West 45th St., New York, N. Y.

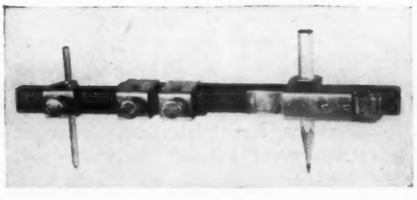
Variable-Speed Transmission

A "single unit" which gives a six to one variation of speed. It is completely self-contained for unit installation between the motor and the driven machine. Speeds are changed by turning handwheel. Pulleys are molded plastic with "Oilite" bearings running on a hardened and ground spindle. Belts are standard V-type. Units can be used for fractional horsepower installations or for transmitting four or five horsepower. The Speedmaster Co., 1301 Washington Ave. South, Minneapolis, Minn.

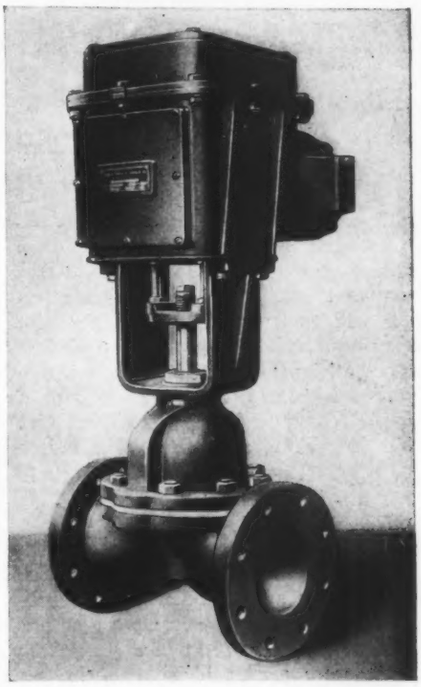


Improved Beam Compass

By means of two connector clamps on this new beam compass, (described originally in *P.E.*, Feb. 1937) two beams can be combined for layout work at a greater radius than the capacity of a single beam. Thus two 36-in. beams, the longest included in the line, can make up a single beam for work on radii up to 68 in. Three single-beam lengths are included in the line, 12, 24 and 36 in., in complete beam-compass assembly. In addition to handling any standard pencil or ruling pen in the roller holder, the compass will take a Stabilo silver pencil for layout work on steel, iron and other metals. This pencil can be used for layout on hot work. A. P. Bartusch, 775 Walnut St., Lockport, N. Y.



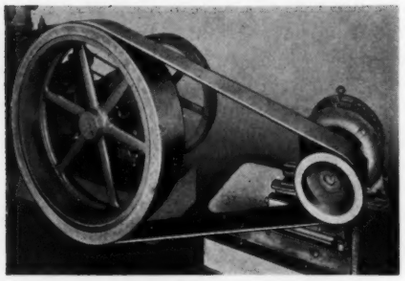
Valve Unit



A new motor-driven valve mechanism designed to operate slip stem valves for heavier pressures and in the larger sizes. A novel power release feature positions the valve at definite open and closed points regardless of variable motor drift. The mechanism can be used either for full open and closed operation or for automatic control with incremental movement proportional to some variable such as pressure or temperature. Strokes up to 10 in. and speeds of 3 to 10 in. per min. are available, with corresponding changes in power. The unit shown is mounted to a 4-in. 150-lb. Saunders Patent Valve and exerts an opening and closing force on the valve stem of 2,000 lb. with 5 in. per min. movement and 2½ in. stroke. Automatic Temperature Control Co., Inc., 34 E. Logan St., Philadelphia, Pa.

Highly Inert Plastic

A new molding material known as Durez 77 SB. For such uses as synthetic yarn equipment that must function in corrosive chemicals, and car water-pump impellers that resist anti-freeze and cleaning compounds. It is also claimed to resist friction wear and permit machining operations without impairment of its water and chemical resistance. General Plastics, Inc., North Tonawanda, N. Y.

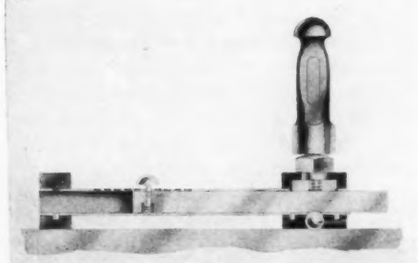


Fiber Laggings for Pulleys

Laggings made of compressed fiber with the end grain on the surface of the same material as in Rockwood paper pulleys. This new lagging has an improved clamp for mounting it on drive pulleys or flywheels. It is claimed that compared with cast iron, the fiber surface will transmit at least 50 per cent more power. Laggings are supplied in any width up to 72 in. in diam. and are applied by clamping on the wheel by a simple clamp. Rockwood Mfg. Co., 1801 English Ave., Indianapolis, Ind.

Portable Hardness Tester

A light-weight portable Brinell instrument, known as the Telebrineller, especially designed for use in close quarters and for applying to parts and equipment that require a portable instrument for testing. The total weight of the outfit and carrying case is only 6½ lb. The instrument is claimed to be not affected by hot or cold weather and is built to stand hard use. Consists of a metal tube supported in a soft rubber head with a rubber spacing block, the tube holding the bar of known hardness with an anvil on top of the rubber head resting directly on the bar. The impression ball is secured in a narrow aperture in the base of the head and comes in direct contact with the metal to



be tested. The spacing bar holds the bar in a clear area for each test. In operation the anvil is struck a sharp blow with the hammer, the impact being transmitted from the anvil to the bar then to the ball and on to the specimen. The relative diameter of the impression in the bar and in the specimen gives the Brinell hardness number. Teleweld, Inc., Railway Exchange Bldg., Chicago, Ill.

Manufacturers' Publications

ALLOY WIRE—Alloy Metal Wire Co., Inc., Prospect Park, Pa. Booklet, 5½x8 in. 36 pages. Data on the wide variety of alloys used in wire, rods and strip form. In addition to listing the description, application and price per pound of alloys, it contains wire data, the range of uses, current temperature characteristics of wire, resistance, etc. Recommended uses and data on wire, rod and strip of Monel and non-corrosive steel are also given.

ARC WELDING ELECTRODE QUANTITIES—General Electric Co., Schenectady, N. Y. Bulletin, 8x10½ in. 8 pages. Tabular data for use in estimating the approximate weight of various kinds of electrodes needed for various types of welded joints.

CERTIFIED STEELS—Joseph T. Ryerson & Sons, Inc., Chicago, Ill. Booklet, 11x15 in. Spiral binding. 28 pages. Setting forth the step by step story of the Ryerson Certified Alloy Steel Plan, accompanied by striking pictures of the procedure. Also contains further information on other certified steels and a page devoted to suggestions for the heat-treater.

CONDENSERS—Erie Resistor Corp., 644 W. 12th St., Erie, Pa. A new bulletin on Erie Ceramicons, a new type of small fixed condenser, describing their unique characteristics and unusual application as compensating condensers.

DATA SHEET—Vanadium-Alloys Steel Co., Latrobe, Pa. Data Sheet No. 937-VL-1. A new sheet for the Metallurgical Data Book containing information pertaining to their Van-Lom grade of steel.

DEVELOPING MACHINE—Ozalid Corp., 354 Fourth Ave., New York, N. Y. Folder containing complete information on the new Ozalid "Type 1000" developing machine, in addition to data and specifications on their other types of developers.

ELECTRODES—Metal & Thermit Corp., 120 Broadway, New York, N. Y. Booklet, 3¼x6 in. 30 pages. Describing their Murex line of heavy coated electros, including the new Vertex and Genex electrodes.

FLEXIBLE TUBING—American Metal Hose Branch, The American Brass Co., Waterbury, Conn. Bulletin SS-3, 8½x11 in. 16 pages. Covering details of construction and specifications of American seamless flexible metal tubing. A variety of applications are illustrated.

HARDNESS TESTING MACHINE—Herman A. Holz, 167 East 33rd St., New York, N. Y. Bulletin 8½x11 in. 16 pages. Following a discussion of the various methods of hardness testing of materials and a detailed presentation of the Vickers test, four types of hardness testing machines manufactured by the company are described. Three of the machines are of new design recently made available.

LETTERING GUIDE—The Wood-Regan Instrument Co., Nutley, N. J. Folder on WRICO lettering guides and pens with supplementary sample sheets to show the actual sizes and styles of lettering in which these guides are available.

MOTORS — Century Electric Co., St. Louis, Mo. Bulletin, 8½x11 in. A new 24-page booklet, well illustrated, presenting in concise form information on how to select the right type of motor, and tables and data on the mechanical and electrical characteristics, with descriptions, of all types of fractional horsepower motors.

NICKEL ALLOYS — The International Nickel Co., Inc., 67 Wall St., New York, N. Y. Booklet, 8½x11 in. 10 pages. Contains a complete list of current literature on production and industrial applications of the nickel alloy steels, nickel cast irons, and nickel alloyed non-ferrous castings. Each publication listed is briefly described.

PISTON RINGS—The Auto-Diesel Ring Co., 1440 East 32d St., Cleveland, Ohio. Loose-leaf bulletin, 8½x11 in. 6 pages. A new service bulletin describing various types of piston rings manufactured by the company including a partial stock list.

PYROMETER CONTROLLER—Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago, Ill. Folder, 8½x11 in. Bulletin 3197. Illustrating and describing the "Alnor" electronic pyrometer controller to automatically control the temperatures of heating devices at a definite predetermined point.

RUBBER DEVELOPMENTS—The B. F. Goodrich Co., Akron, Ohio. An attractive booklet containing 29 reprints of a series of Goodrich advertisements, each of which is devoted to some outstanding rubber developments, covering a variety of products.

SOLVENT DEGREASING—G. S. Blakeslee & Co., 19th St. and 52d Ave., Chicago, Ill. Booklet, 8½x11 in. 10 pages. Information covering the Blakeslee process and the more specific uses of solvent degreasing machines and presenting the advantages of these machines in various cleaning departments.

TANTALOY TIPPED TOOLS — Fansteel Metallurgical Corp., North Chicago, Ill. Folder, 8½x11 in. 6 pages. Following a description of the unusual characteristics of Tantaloy, drawings of standard tool shapes are presented, together with a table listing standard shank and tip dimensions, tool numbers, tip numbers, and price list of finished tools, milled and brazed tools, and plated tips for brazing.

TIMER.—Walser Automatic Timer Co., Graybar Bldg., New York, N. Y. Bulletin, 8½x11½ in. 12 pages. Illustrations and pertinent data and specifications on a variety of their automatic timers and typical applications.

AIR CONDITIONING PRODUCTS—Julien P. Friez & Sons, Inc., Baltimore, Md. Bulletin K, 8 pages, 8½x11 in. Containing illustrations, brief descriptions and price lists of the Friez complete range of instruments for automatic controlling, indicating, recording and testing, and measuring of a wide variety of air conditions.

BEARINGS—The Timken Roller Bearing Co., Canton, Ohio. Supplement to Timken Engineering Journal, 52 pages, 8½x11 in. Describes and illustrates the various applications of single and double-row bearings to oil field equipment.

BELTS—Manhattan Rubber Mfg. Div., Raybestos-Manhattan, Inc., Passaic, N. J. Bulletin, 4 pages. Covering advantages of their Condor compensated belts and engineering data for proper selection and application.

TAP AND SETSCREWS—Dardelet Threadlock Corp., 55 Liberty St., New York, N. Y. Bulletin 17, 4 pages,, 8½x11 in. Covering the application of the Dardelet self-locking thread on tap and setscrews advantages and applications.

CONTROLOGRAPH—American Schaeffer & Budenberg Instrument Div., Manning, Maxwell & Moore, Inc., Bridgeport, Conn. Catalog, 24 pages, 7¾x10¾ in. Describing the temperature and pressure Controlograph and its adaptability to process control applications.

CONTROL VALVES—The Bristol Co., Waterbury, Conn. Bulletin 461. Covering the constructional features and operating characteristics of the various types of Bristol synchro-diaphragm valves and their application to typical installations where temperature, pressure, liquid level, flow and humidity are controlled pneumatically.

COUNTERS—Durant Mfg. Co., 1929 N. Buffum St., Milwaukee, Wis. Catalog Section No. 20, 4 pages, 8½x11 in. A condensed catalog of Durant Productimeters, illustrating and briefly describing 50 styles of counting and registering instruments to aid in selecting the counter most suitable for a particular application.

COUPLINGS — Continental-Diamond Fibre Co., Newark, Del. Folder, 8½x11 in. Technical data on the new Celoron molded plastic coupling.

ELECTRICAL EQUIPMENT—Colt's Patent Fire Arms Mfg. Co., Hartford, Conn. Catalog 60, loose-leaf, 8¾x10¾ in. More than 100 pages of data and specifications covering Colt-Noark electrical products, divided into sections covering safety switches, industrial control equipment, service equipment and accessories, and a section devoted to fuses, cut-outs, clips and solderless lugs. A folder containing complete price lists is included.

EXPANSION JOINTS—Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa. Bulletin EJ-1906 to replace Section EJ-1905, 16 pages, 8½x11 in. Descriptive data on Yarway expansion joints, illustrations of typical installations, numerous specification tables and a table for figuring expansion in pipe lines. Considerable space is devoted to the Yarway Gun-Pakt expansion joint which can be packed while under pressure.

FLEXIBLE COUPLINGS — Ajax Flexible Coupling Co., Westfield, N. Y. Catalog, 15 pages, 11x8½ in. Technical data sheets and blue prints covering the Ajax line of flexible couplings.

FURNACES—General Electric Co., Schenectady, N. Y. Bulletin GEA-2790, 12 pages, 8½x11 in. Describing their conveyor type electric furnaces for scale-free hardening.

HEAT-TREATING FURNACES — Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa. Broadside "T". Illustrating and describing their complete line of furnaces for hardening, tempering and nitriding.

LACQUER—Roxalin Flexible Lacquer Co., Elizabeth, N. J. Two folders, 9x11 in. Product summaries giving the properties of: Blue Knight Roxyn C, a synthetic, air-drying or baking flexible lacquer resistant to perspiration and highly corrosive chemicals, and Cadmium Water Dip Lacquer No. 3850, a clear, cellulose, air-drying lacquer which prevents the oxidation, fuming or marring of cadmium plate.

LAMINUM—Laminated Shim Co., Inc., 21-24 44th Ave., Long Island City, N. Y. Specifications File folder for quick reference, containing detailed specifications on laminated brass shim stock, including essential information on the materials, their composition and degree of lamination, stock size, etc.

LIFTING MAGNETS—The Ohio Electric Mfg. Co., Cleveland, Ohio. Bulletin 110, 14 pages, 8½x10¾ in., describing improved lifting magnets and magnet controllers.

LIFTING MAGNET CONTROLLERS—The Electric Controller & Mfg. Co., Cleveland, Ohio. Folder, 8½x11 in. Descriptive data and specifications on their new adjustable automatic-discharge magnet controller.

MERCURY SWITCHES — General Electric Vapor Lamp Co., Hoboken, N. J. Catalog 603, 12 pages, 8½x11 in. Describing the complete line of GE Kon-nec-tor mercury switches, showing full-size illustrations of the 12 common types of mercury-to-mercury and mercury-to-metal switches. A table shows the capacity and electrical specifications of each type.

PHOTOELECTRIC POTENTIOMETER—Weston Electrical Instrument Corp., Newark, N. J. Bulletin, 4 pages, 8½x11 in. Describing the operating characteristics and fields of application for the Weston Model 721 photoelectric potentiometer and its related equipment.

PIPE, FITTINGS, VALVES, ETC.—Haveg Corp., Newark, Del. Bulletin A-1, 8 pages, 8½x11 in. Complete data on standard size Haveg pipe, fittings, valves and fume duct for handling corrosive liquids or fumes.

PYROMETERS—The Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa. Catalog 1102, 48 pages, 8½x11 in. Covering the complete line of Brown potentiometer pyrometers—indicating, recording and controlling and the new Electr-o-Line controllers and proportioning control system.

SPRING WASHERS—The National Lock Washer Co., Newark, N. J. Data Chart, 12½x18 in. Giving recommended standard sizes, manufacturing tolerances and sections for spring washers. The chart is suitable for hanging.

SHAFTING—La Salle Steel Co., Palmolive Bldg., Chicago, Ill. Booklet, 16 pages, 5½x8½ in. A guide for the proper selection of materials for shaft applications.

SPOT WELDER AND WELDER TIPS—Eisler Engineering Co., 750 South 13th St., Newark, N. J. Catalog 38W, 100 pages. Illustrations, specifications and descriptions presenting the important features of the many types of spot and butt welders, wire portable and special welders, high frequency and brazing and soldering machines, spot welding timers and miscellaneous welding accessories. Contains sketches and drawings of various types of spot and butt welding and more than 1,250 illustrations on various welding problems.

STAINLESS STEEL ELECTRODES—Page Steel & Wire Div., American Chain & Cable Co., Inc., Monessen, Pa. Booklet, 10 pages, 8½x11 in. Illustrating and describing their line of electrodes suitable for welding practically every commercial composition of stainless steel.

STEEL—Timken Steel & Tube Div., The Timken Roller Bearing Co., Canton, Ohio. Third edition of the booklet "Digest of Steels for High Temperature Service," 28 pages, 8½x11 in. Covering all steels normally used in the high temperature field. In addition to an analysis of each steel and a brief discussion of recommended applications, numerous tables of physical properties are presented.

STEEL—United States Steel Corporation Subsidiaries, 434 Fifth Ave., Pittsburgh, Pa. Booklet, 68 pages, 8½x11 in. Spiral bound. A well-illustrated and presented booklet "USS COR-TEN—The Low-cost, High-strength, Corrosion-resisting Steel of Many Uses," presenting the advantages that USS COR-TEN steel offers to railroads and other industries.

TANK HEADS AND STAMPINGS—The Commercial Shearing & Stamping Co., Youngstown, Ohio. Booklet, 28 pages, 8½x11 in. The standard products and a few special items manufactured by the company are described and illustrated. Tables of standard sizes, dimensions and proportions accompany each of the items.

TRANSFORMERS—General Electric Co., Schenectady, N. Y. Folder GEA-2424B, 8½x11 in. Data on transformers and protective equipment for 6900-volt (line to ground), solidly grounded, common-neutral circuits.

TUBE COUPLINGS—Packless Metal Products Corp., 37-14 29th St., Long Island City, N. Y. Bulletin 500, 10 pages, 8¾x11¼ in. Specifications and data sheets on self-flaring tube couplings.

WASHERS AND STAMPINGS — Wrought Washer Mfg. Co., 2100 S. Bay St., Milwaukee, Wis. A new catalog entitled "Over 20,000 varieties," covering their line of washers and stampings.

WELDING ELECTRODES — Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Catalog Section 26-640, 4 pages, 8½x11 in. Covering their three available grades of crucible weld electrodes for a.c. welding, sizes available and applications.

Books and Bulletins

Mechanics

WILLIAM F. OSGOOD. *495 pages, 6x9 in. 157 figures. Red cloth binding. Published by The Macmillan Co., 60 Fifth Ave., New York, N. Y. Price $5.00.*

In this volume the author has attempted "to unite a broad and deep knowledge of the most elementary physical phenomena in the field of mechanics with the best mathematical methods of the present day, treating with completeness, clarity, and rigor the beginnings of the subject; in scope not restricted, in detail not involved, in spirit scientific."

The book is designed as a careful and thorough introduction to mechanics, and is adapted to the needs of a first course in the subject. The contents include chapters on: statics of a particle, statics of a rigid body, motion of a particle, dynamics of a rigid body, kinematics in two dimensions, rotation, work and energy, impact, and relative motion and moving axes. Lagrange's equations and virtual velocities, Hamilton's canonical equations, d'Alembert's principle, Hamilton's principle and the principle of least action, contact transformations, and solution of Hamilton's equations are also thoroughly covered.

The appendix contains a study of vector analysis, it also shows how d'Alembert's principle and Lagrange's equations apply to a class of problems which are of great importance in physics. Numerous problems are included for practice in applying the principles set forth throughout the book.

Manual of Gear Design

Section Three

EARLE BUCKINGHAM. *172 pages, 8½x11 in. Blue cloth binding. Published by The Industrial Press, 148 Lafayette St., New York, N. Y. Price $2.50.*

This third volume of the "Manual of Gear Design" deals with the working data peculiar to the design mathematics related to helical gears with parallel axes and spiral gears with non-parallel non-intersecting axes. The book is made up in plate form and arranged so that the designer can readily review the factors that enter into the problem at hand and proceed toward a solution.

Definitions of various gear terms and an explanation of the symbols and notations employed in the formulas throughout the book are thoroughly covered in the first chapter. The applications of all formulas are illustrated with examples. Many tables are included that make unnecessary the calculation of the various proportional factors which are inherent in gear problems. Much information and data are presented concerning the hobbing, shaping and milling of helical and spiral gears. Other portions of the volume deal with internal helical gears, planetary drives, end thrust and bearing loads, herringbone gears, backlash, tooth loads, standard tooth forms, power transmitting capacities and speed reducers.

Engineering Mechanics

Dynamics

S. TIMOSHENKO AND D. H. YOUNG. *317 pages, 6x9 in. Blue clothboard covers. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $2.75.*

Written for a college textbook, the authors have adhered strictly to the fundamentals of the subject in order to show how to attack the problem, demonstrating the methods by illustrating their application to practical engineering problems. Subject matter covers rectilinear translation, curvilinear translation, rotation of rigid bodies about a fixed axis, plane motion of rigid bodies and relative motion. Recognizing the great importance of vibration in modern engineering design, the authors have included several articles dealing with vibration problems.

The authors have made a free use of elementary calculus and elementary differential equations, although the solutions are given in such detail with respect to differential equations, that the user of the book need not have any special preparation in this subject.

Engineering Mechanics

Statics

S. TIMOSHENKO AND D. H. YOUNG. *330 pages, 6x9 in. Blue clothboard covers. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $2.75.*

In the preface the authors state, "It seems evident that university training in such a fundamental subject as mechanics must seek to build a strong foundation, to acquaint the students with as many general methods of attack as possible, to illustrate the application of these methods to practical engineering problems, but to avoid routine drill in the manipulation of standardized methods with solutions." Such is the aim of the book and the authors are to be congratulated on the success with which they have accomplished that aim.

Written primarily for use as a textbook in engineering universities, the book covers all phases of the subject of statics with a rather complete presentation of the general theory of statically determinate trusses and frames and a chapter on the principle of virtual displacement, that is, the method of determining an unknown force by equating the work done by the unknown force with that done by a known force when the mechanism or body is given an infinitesimally small displacement.

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Tubular Heat Exchanger Standards

TUBULAR EXCHANGER SECTION. *Loose-leaf, 8½x11 in. Published by the Heat Exchange Institute, 90 West St., New York, N. Y. Price 75 cents.*

Covering mechanical, construction and thermal standards for shell and bare tube heat exchangers. Includes data on exchanger shells, tube sheets, baffles, support plates, tubes, material specifications, fouling factors and thermal design data.

How to Determine the Size of Gears

G. E. KATZENMEYER. *Bulletin No. 3, 24 pages, 8½x11 in. Published by the National-Erie Corp., Erie, Pa.*

Presenting data and information compiled as a standard procedure in determining the size and horsepower capacities of gears of different materials. Comparative tables and charts eliminate complicated mathematical equations and are also helpful for selecting the most economical and best type of gearing to suit the conditions when designing a set of gears.

Tests of Steel Columns

WILBUR M. WILSON. *42 pages, 6x9 in. Paper covers. Bulletin No. 292, Engineering Experiment Station. Published by the University of Illinois, Urbana, Ill. Price 50 cents.*

A report of a series of tests that have been made from time to time during the past six years on steel columns of different types. The columns are grouped as follows: thin cylindrical shells, laced channels and angle struts.

Welding Symbols and Instructions for Their Use

12 pages, 9x12 in. Published by the AMERICAN WELDING SOCIETY, *33 West 39th St., New York, N. Y. Price 25 cents.*

Standard welding symbols covering both fusion and resistance welding, to supersede the former symbols originally published by the Society in 1929 and revised in 1935. These symbols have been recommended to the American Standards Association for adoption as American standards.

PRODUCT ENGINEERING + REFERENCE BOOK SHEET

Starting Torque of Split-Phase Motors — II

Various formulas for calculating starting torque

A. F. PUCHSTEIN and T. C. LLOYD
Robbins & Myers, Inc.

TO FACILITATE checking, various formulas for calculating starting torque will be given. With several available, it is important to know which is the most accurate and what approximations, if any, have been made in the derivation.

Of first importance is a consideration of the circuit to which the motor is assumed to be equivalent. In Fig. 1 are shown the circuit elements.

(*a*) If the magnetizing current is neglected as in Fig. 1 (*a*): $I_2=I_1$, $R=r_1+r_2$, and $X=x_1+x_2$

(*b*) If the magnetizing branch is considered, as shown in Fig. 1(*b*), the presence of the magnetizing current brings about the following relationships:

$$I_2=\frac{-jX_m}{r_2+j(X_m+x_2)} \text{ or } \frac{X_m}{\sqrt{r_2^2+(X_o'')^2}}$$

$$Xo''=X_m+x_2$$

$$R=r_1+\frac{X_m^2\, r_2}{r_2^2+(X_o'')^2}$$

$$X=x_1+(X_m)\left[\frac{r_2^2+X_o''x_2}{r_2^2+(X_o'')^2}\right]$$

(*c*) Considering the magnetizing branch as in (*b*) but making the assumption that r_2 is negligibly small in obtaining the ratios:

$$I_2=I_1\sqrt{K_r}$$

$$R=r_1+K_r r_2$$

$$X=x_1+x_2\sqrt{K_r}$$

In the formulas:

Subscript *m* implies magetizing reactance.

$$X_m=X_o\sqrt{K_r}$$

Subscript *M* implies main winding, *S* for start.

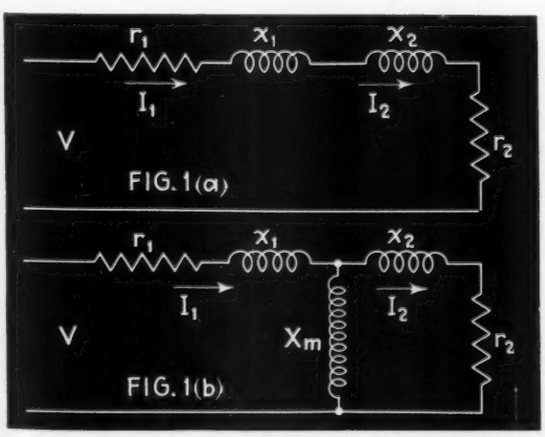

Fig. 1—Two equivalent circuits of the single-phase induction motor as standstill, main or start winding

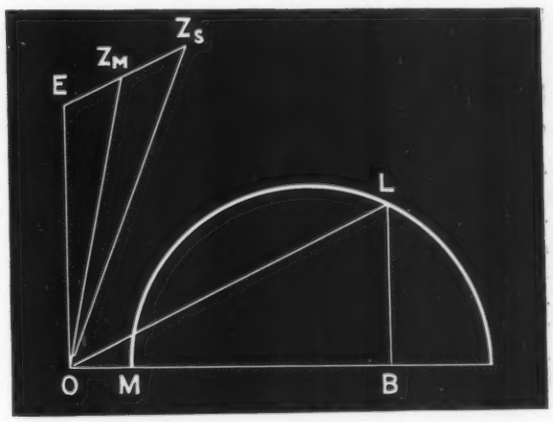

Fig. 2—Elementary diagram for calculating the starting conditions of the split-phase motor

Subscript *1* for stator, *2* for rotor or secondary.

The value used for r_2 is that calculated as shown in Part 1. (See *Product Engineering*, June 1937, p. 243, Vol. 8, No. 6.) Usually this should be multiplied by a "skin factor" of 1.1 to 1.3 for greater accuracy.

Method 1. Modified LaTour diagram.

Two-phase: Starting Torque (oz. ft.)

$$=\frac{225.4}{\text{Syn.r.p.m.}}\text{ (Power to rotor from one phase).}$$

Split-phase as imperfect two-phase motor:

$$\text{Starting Torque (oz. ft.)} = \left(\frac{225.4}{\text{Syn.r.p.m.}}\right)\left(\frac{P_M\phi_s \sin\theta_t}{\phi_M}\right)$$

P_M=Watts delivered to rotor from the main phase
ϕ_s=flux reaching rotor from the start winding
ϕ_M=flux reaching rotor from the main winding
ϕ_t=the time phase angle between ϕ_s and ϕ_M

Refer to Fig. 2.

$\overline{OL}$=rotor-blocked or starting current, main winding
$\overline{LB}$=in-phase component of this current
$\overline{OE}$=counter e.m.f.
$\overline{EZ}_M$=resistance drop in the stator main winding
$\overline{EZ}_s$=resistance drop in the stator start winding

Working formula: (Using diagram)

$$\text{St.T. (oz.ft.)} = \left(\frac{225.4\ V}{\text{Syn. r.p.m.}}\right)\left(\frac{\overline{OE}}{\overline{OZ}_M}\right)\left(\frac{\overline{OE}}{\overline{OZ}_S}\right)\left(LB.\ a\sin\theta_t\right)$$

a=ratio of transformation

$$= \frac{\text{Series conductors x winding factor (main winding)}}{\text{Series conductors x winding factor (start winding)}}$$

$$= \frac{X_M}{X_S} \text{ (approximately)}$$

X_M = total leakage reactance, main winding
X_s = total leakage reactance, start winding

Working formula: (Analytical calculations)

$$\text{St.T. (oz.ft.)} = \left(\frac{225.4\ V^2 a}{\text{Syn. r.p.m.}}\right)(K_r r_2)\left(\frac{Z_S'}{Z'_M}\right)\left(\frac{X_M R_S - R_M X_S}{Z_M^2 Z_S^2}\right)$$

$$Z'_M = \sqrt{(K_r r_2)^2 + X^2_M}$$

$$Z_M = \sqrt{(r_{1M} + K_r r_2)^2 + X_M^2}$$

$$Z_S' = \sqrt{\left(\frac{K_r r_2}{a^2}\right)^2 + X_S^2}$$

$$Z_S = \sqrt{\left(r_{1S} + \frac{K_r r_2}{a^2}\right)^2 + X_S^2}$$

$$R_M = r_{1M} + K_r r_2$$

$$R_S = r_{1S} + \frac{K_r r_2}{a}$$

r_{1M} = resistance of stator main winding
r_{1S} = resistance of stator start winding
θ_M = angle between applied voltage and stator main current
θ_s = angle between applied voltage and stator start current

$$\sin\theta_t = \sin(\theta_M - \theta_S) = \frac{X_M R_S - R_M X_S}{Z_M Z_S}$$

Maximum starting torque occurs when the constants are so proportioned that:

$$r_{1S} = \frac{r_{1M} + Z_M}{a^2}$$

Method 2. Modified Morrill Analysis.

The reduction of the capacitor motor equations as given by W. J. Morrill, so as to make them applicable to the ordinary split-phase motor, results in the following:

Working formula:

$$\text{St. T.} = \left(\frac{4R_f}{a}\right)(Ah - Bg) \text{ in synchronous watts}$$

$$\text{St. T. (oz. ft.)} = (112.7)\left(\frac{\text{Synchronous Watts}}{\text{Syn. r.p.m.}}\right)$$

$$R_f = \frac{0.5 r_2 X_M^2}{r_2^2 + (X_o'')^2}$$

$$R_M = r_{1M} + \frac{X^2_M r_2}{r_2^2 + (X_o'')^2}$$

$$R_S = r_{1S} + \frac{X^2_M r_2}{a^2[r_2^2 + (X_o'')^2]}$$

$$X_M = x_{1M} + X_M\left(\frac{r_2^2 + X_o'' x_2}{r_2^2 + (X_o'')^2}\right)$$

$$X_S = x_{1S} + \frac{X_m(r_2^2 + X_o'' x_2)}{a^2[r_2^2 + (X_o'')^2]}$$

$$Z_M = R_M + jX_M$$
$$Z_S = R_S + jX_S$$

$$I_M = \frac{V}{Z_M} = A + jB$$

$$I_S = \frac{V}{Z_S} = g + jh$$

j = operator

Simplified by the flux factor, K_r. Method (c) rather than (b)

$$\frac{X_M^2}{r_2^2(X_o'')^2} \cong \frac{X_M^2}{(X_o'')^2} = K_r \text{ when } r_2 \text{ is neglibly small.}$$

Resulting method as alternate from that given above:

$$R_f = 0.5\ K_r r_2$$
$$R_M = r_{1M} + K_r r_2$$
$$R_S = r_{1S} + \frac{K_r r_2}{a^2}$$
$$X_M = x_{1M} + x_2\sqrt{K_r}$$
$$X_S = x_{1S} + (x_2\sqrt{K_r})/a^2$$
$$(Ah - Bg) = \frac{V^2(X_M R_S - R_M X_S)}{Z_M^2 Z_S^2} = V^2\frac{\sin\theta_t}{Z_M Z_S}$$

Resulting working formula:

$$\text{St.T. (oz.ft.)} = \left(\frac{225.4 V^2}{\text{Syn. r.p.m.}}\right)\left(\frac{r_2 K_r}{2}\right)\left(\frac{X_M R_S - R_M X_S}{Z_M^2 Z_S^2}\right)$$

Except when the winding distribution of the main and start windings are widely different:

$$\frac{1}{a} = a\left(\frac{Z_S'}{Z'_M}\right)$$

When this substitution is made, the above equation for starting torque is identical with that of method 1.

Method 3. Modified Boothby (Capacitor Motor) Analysis.

The reduction of the capacitor motor starting torque equation of C. R. Boothby, by elimination of capacitor terms, yields a working formula for the ordinary split-phase motor as follows:

$$\text{St.T. (oz.ft.)} = V^2\left(\frac{1.88\ P}{f}\right)\left(\frac{r_2}{a}\right)\left(\frac{R_S X_M - R_M X_S}{Z_M^2 Z_S^2}\right)$$

P = poles
f = frequency

Final results obtained by this equation depend of course upon the method of defining R_s, X_M, etc. A correction for magnetizing current has been suggested by P. H. Trickey, through multiplying by the factor $\frac{K_r}{1 + (r_2/X_o)^2}$. This factor is equivalent to $\frac{X_M^2}{X_o^2 + r_2^2}$ and is approximately equal to K_r.

Using this factor, and defining R_s, X_M, etc. as in Method 1 results will be practically identical with those obtained by Method 1. A difference may result from winding distributions such that $1/a$ may be unequal to $(aZ_s)/Z'_M$.

Material in these calculation processes (Parts I and II) are taken in part from the work of C. A. Adams, E. Arnold, B. A. Behrend, C. R. Boothby, W. J. Branson, I. S. Campbell, B. La Tour, W. J. Morrill, and P. H. Trickey.